ANNUAL HISTORICAL REPORT
CALENDAR YEAR 1988

U S ARMY RESEARCH INSTITUTE
OF
ENVIRONMENTAL MEDICINE
Natick, Massachusetts

UNITED STATES ARMY
MEDICAL RESEARCH & DEVELOPMENT COMMAND

ANNUAL HISTORICAL REPORT - AMEDD ACTIVITIES,

RCS MED-41 (R4)

U.S. ARMY RESEARCH INSTITUTE OF ENVIRONMENTAL MEDICINE

NATICK, MASSACHUSETTS 01760

CALENDAR YEAR 1988

USARIEM
CY88

GENERAL INFORMATION

ORGANIZATION

The United States Army Research Institute of Environmental Medicine (USARIEM) is organised with an Office of the Commander/Scientific Technical Director, seven Research Divisions and a Research Support Division consisting of five functional Branches. Organization chart of USARIEM, dated 1 October 1988 is attached as Appendix A.

LOCATION

USARIEM is located at the United States Army Natick Research Developoment and Engineering Center (USANRDEC), Natick, Massachusetts 01760.

ACTIVATION AND ASSIGNMENT

a. By Section VI, General Order 33, Headquarters, Department of the Army, 20 September 1961, USARIEM was established as Class II activity under the jurisdiction of The Surgeon General, effective 1 July 1961.

b. General Order No. 40, Department of the Army, Office of the Surgeon General, 1 December 1961, assigned USARIEM to the United States Army Medical Research and Development Command, Washington, DC, effective 1 July 1961.

c. The USARIEM was last reorganized under General Order No. 32, Department of the Army, Headquarters, U.S. Army Medical Research and Development Command on 1 August 1975.

TENANCY

a. USARIEM is a tenant on the USANRDEC installation and receives administrative and logistical support from the USANRDEC on a reimbursable basis in accordance with an annually renewed intra-Service support agreement.

b. The Pikes Peak Laboratory Facility, Colorado, is a subordinate activity of the USARIEM and is utilized on a seasonal basis when a research requirement exists.

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MISSION

Conducts research on the effects of temperature, altitude, work and nutrition on the health and performance of the individual soldier and combat crews operating Army systems. Assesses decrements to soldier or combat crew performance caused by the synergy of environmental extremes protective measures used in NBC sustained operations. Conducts research on the biomedical processes limiting physical performance to determine physical fitness requirements and seek solutions to medical problems related to physical training and exercise. Defines the complex interaction of environmental/operational stress and Army systems and develops, evaluates and assists in the implementation of strategies designed to protect the soldier and enhance performance. In coordination with the Natick Research, Development & Engineering Center (Natick) and through liason with other Federal agencies, conducts research to develop the technology base required to evaluate feeding strategies for operation rations and supplements to minimize soldier performance decrements under sustained combat conditions and discharge the Army Surgeon General's responsibilities as DOD executive agent for nutrition. Assists Natick in the development of personal clothing and equipment by assessing the physiological impact of these items under all climatic conditions. Provides technical advice and consultant services to Army commanders, installations and activities in support of the Army Preventive Medicine Program and, on request to other Federal agencies.

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PERSONNEL

STRENGTH AS OF: 31 December 1988

CIVILIANS	AUTHORIZED	ACTUAL
SES	1	1
GM	7	7
GS	79	69
WG	2	2
FTP	2	10
	91	89

OFFICERS	AUTHORIZED	ACTUAL
MC	5	3
MS	12	11
VC	2	2
SP	2	2
	21	18

ENLISTED	AUTHORIZED	ACTUAL
	54	55

KEY STAFF AS OF: 31 DECEMBER 1988

David D.Schnakenberg, COL, MS, Ph.D., Commander and Scientific/Technical Director

Lawrence K. Lightner, MAJ, MS, Ph.D., Executive Officer and Director, Research Support Division

Williams, Charles E., SFC, Chief Medical NCO

James A. Vogel, Ph.D., Director, Exercise Physiology Division

Kent B. Pandolf, Ph.D., Director, Military Ergonomics Division

Richard R. Gonzalez, Ph.D., Chief,Biophysics Branch, Military Ergonomics Division

Michael N. Sawka, Ph.D., Chief, Physiology Branch, Military Ergonomics Division

Roger W. Hubbard, Ph.D., Director, Heat Research Division

Allen Cymerman, Ph.D., Director, Altitude Research Division

Murray P. Hamlet, D.V.M., Director, Cold Research Division and Acting Chief, Cold Injury Branch

Wilbert D. Bowers, Ph.D., Chief, Experimental Pathology Branch, Cold Research Division

Andre A. Darrigrand, MAJ, VC, D.V.M., Chief, Animal Care Branch, Cold Research Division

Eldon W. Askew, LTC, MS, D.V.M., Director, Military Nutrition Division

Terry M. Rauch, MAJ, MS, Ph.D., Director, Health and Performance Division

RESEARCH SUPPORT DIVISION:

Jacqueline F. Amaya, 2LT, MS, Adjutant/Detachment Commander
Vacant- Chief, Logistics Branch
John M. Foster, Chief, Bioengineering Branch
Marie E. Stephens, Personnel/Manpower Resource Management Branch
Violet M. Trainer, Program and Budget, Resource Management Branch
Vacant - Chief, Information Management Branch

ALLOCATION AND FUNDING

USARIEM - FY 1988 PROGRAM

DA PROJECT NO. & TITLE	FUNDS
3M161102BS15 - Science Base of Systems Health Hazard Research	$1,680,000
3E62787A3GL - Management and Administration	1,613,000
3E162787A875 - Medical Defense Against Chemical Agents	173,000
3E162787A878 - Health Hazards of Military Materiel	299,000
3E162787A879 - Medical Factors Enhancing Soldier Effectiveness	878,000
3M263002D819 - Field Medical Protective Device - Medical Protection Using Nutrition	428,000
3M263002D995 - Medical Countermeasures to CW Agents	379,000
3M463751D993 - Medical Defense Against Chemcial Warfare- Pretreatment, Nerve Agent (Pyridostigmine - Sustained Rel.)	439,000
Total FY88 Program	$5,889,000

SUPPLY AND MAINTENANCE ACTIVITIES

During CY88 a total of 1,102 requests were processed by the Logistics Branch as indicated below:

Non-Expendables - 174 Requests
Expendables - 928 Requests

During CY88, a total of 2354.2 hrs were used by the Medical Maintenance Section as indicated below:

Scheduled Services - 584.5 hrs
Unscheduled Services - 769.7 hrs

During CY88, there were 440 items processed for calibration.

BUILDING AND FACILITY EQUIPMENT

DESIGN AND DEVELOPMENT:

The Bioengineering Branch contributed to the design and development of the following for the period, CY88:

a. Designed and developed one prototype in-shoe activity/recording device to measure soldier activity levels in the field.

b. Developed specialized ergometer tachometer for underwater exercise.

c. Designed and developed an automated data acquisition and recording system to measure human response/reaction times for the Weaponeer Marksmanship Simulator.

d. Initiated design of a laser tracking device to measure human performance while tracking moving targets.

e. Developed a digital instrumentation system to analyze physiological responses to vibratory excitation.

f. Designed and developed a unique hand-cooling apparatus to test handwear under simulated extreme cold conditions.

g. Designed and developed an electro mechanical mass transfer calibration device for the direct evaluation of convective heat transfer coefficients by napthalene sublimation

h. Completed the design and fabrication of an artificial horizon visual disturbance apparatus to predict sensitivity to altitude exposure.

BUILDING MODIFICATIONS:

a. New x-ray system installed in Animal Care Facility.

b. Back-up air compressor installed for the building air pressure system.

c. New flooring installed for the penthouse animal holding area.

d. New air-conditioning system installed for the central computer room..

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OFFICE OF THE COMMANDER

PUBLICATIONS:

DeLuca, J.P., L.E. Armstrong, E.L. Christensen, R.W. Hubbard, J.A. Vogel, D.D. Schnakenberg. Mass to Surface Area Ratio in Military Personnel. USARIEM Technical Report No. T21-88, 1988.

Rose, M.S., J.C. Buchbinder, T.B. Dugan, E.G. Szeto, J.D. Allegretto, R.W. Rose, D.E. Carlson, K.W. Sammonds and D.D. Schnakenberg. Determination of nutritional intakes by a modified visual estimation method and computerized nutritional anaylsis for dietary assessments. USARIEM Technical Report No. T6-88, 1988.

KEY BRIEFINGS:

David D. Schnakenberg, COL, MS, Ph.D. - Presented briefing on the Congressionally mandated military nutrition research project at Louisiana State University at Quarterly Meeting of the Interagency Committee on Human Nutrition Research, Washington, DC, 19 Jan 1988.

David D. Schnakenberg, COL, MS, Ph.D. - Presented briefing on USARIEM's Military Nutrition Research Program to GEN(Ret.) Sennewald and the HQDA Army Food 2000 Task Force, Pentagon, Washington, DC, 28 Jan 1988.

David D. Schnakenberg, COL, MS, Ph.D. - Present and discuss plans to implement military nutrition research project at LSU to NAS/NRC Committee on Military Nutrition Research, Washington, DC, 4 Feb 1988.

David D. Schnakenberg, COL, MS, Ph.D. - Present annual report of Research Study Group 8, Nutritional Aspects of Military Feeding at parent NATO Panel VIII, Meeting at NATO HQs, Brussels, Belgium, 18-19 Apr 1988.

David D. Schnakenberg, COL, MS, Ph.D. - Present overview of DoD Nutrition Research Program at Quarterly Meeting of Interagency Committee on Human Nutrition Research, Washington, DC, 12 Jul 1988.

David D. Schnakenberg, COL, MS, Ph.D. - Present summary of final report, Research Study Group 8, Nutritional Aspects of Military Feeding at parent NATO Panel VIII Meeting, Wachtberg-Werthhoven, FRG, 13-14 Oct 1988.

David D. Schnakenberg, COL, MS, Ph.D. - Provided invited lecture "Research for the Soldier at USARIEM" to Univ Mass ROTC Dining In, Amherst, MA, 18 Nov 1988.

David D. Schnakenberg, COL, MS, Ph.D. - Present review of FY89 USARIEM budget issues to MG Russell, CG, USAMRDC and Staff, FT Detrick, MA, 22 Nov 1988.

David D. Schnakenberg, COL, MS, Ph.D. - Briefed Mr. Louis Cabot, Member, Secretary of Defense Commission on Base Realignment on USARIEM's Research Program, Natick, MA, 7 Dec 1988.

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SIGNIFICANT TDY:

David D. Schnakenberg, COL, MS - Inititate planning to implement Congressionally directed nutrition research grant to Louisiana State Univ (LSU), Baton Rouge, LA, 8-9 Jan, 1988.

David D. Schnakenberg, COL, MS - Attend briefing by MAJ Bruce Jones on USARIEM's training injuries reduction research program to LTG Quinton Becker, The Surgeon General of the Army, Falls Church, VA, 14 Jan 1988

David D. Schnakenberg, COL, MS - Coordination meeting with MG Russell, BG Travis and USAMRDC Staff, COL Cronin and COL Ranadive, OTSG to develop strategy to implement nutrition research project at LSU, FT Detrick, MD, 22 Jan 1989.

David D. Schnakenberg, COL, MS - Participate in planning meeting with USAMRDC, TRADOC, WBAMC, and OTSG and USARIEM Staff on training injuries reduction research, FT Detrick, MD, 3 Feb 1988.

David D. Schnakenberg, COL, MS - Attend USAMRDC Commanders Conference, FT Detrick, MD, 8-10 Feb 1988.

David D. Schnakenberg, COL, MS - Coordinate initial plans for $3.5m nutrition research program at LSU with USAMRDC (BG Travis, et al), LSU (Dr. Braymer, Dr. Rigby, Mr. Silvia), OTSG (COL Cronin, CPT Tingel), USDA(Dr. Coombs, Mr. Victor) and NAS/NRC Military Nutrition Committee (Dr. Neshiem). Meeting held at FT Detrick, MD, 12 Feb 1988.

David D. Schnakenberg, COL, MS - Participate in Army Materiel Command Technology Base Investment Strategy Conference Working Sub-Group on Individual/Collective Protection and Sustainment, Laurel, MD, 2 Mar 1988.

David D. Schnakenberg, COL, MS - Attend briefing by CPT Eileen Szeto on USARIEM's Garrison Dining Hall Nutrition Studies to the Honorable John Marsh, Secretary of Army and the HQDA Planning Committee for Physical Fitness, Pentagon, Washington, DC, 24 Mar 1988.

David D. Schnakenberg, COL, MS - Coordinate plans for nutrition research grant at LSU, Baton Rouge, LA, 29-30 Mar 1988.

David D. Schnakenberg, COL, MS - Coordinate nutrition food and environmental medicine research with LTC Ernst Hillert, Surgeon Generals Office, Bonn, FRG and LTC Wolf von Restorff, Zentrales Institute Des Sanitatsdienstes der Bandeswehr, Koblenz, FRG, 21-22 Apr 1988.

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SIGNIFICANT TDY:

David D. Schnakenberg, COL, MS - Participate in HQDA Army Food 2000 Task Force Meeting, Pentagon, Washington, DC, 17 May 1988.

David D. Schnakenberg, COL, MS - Participate in HQDA review of Army Food 2000 Task Force draft report, Pentagon, Washington, DC, 24 May 1988.

David D. Schnakenberg, COL, MS - Attend Army Food 2000 Task Force briefing to LTG Ross, DCSLOG, Pentagon, Washington, DC, 31 May 1988.

David D. Schnakenberg, COL, MS - Participate in General Officer In-Process Review (IPR) of Combat Field Feeding System, FT Lee, VA, 1-2 Jun 1988.

David D. Schnakenberg, COL, MS - Participate in 12th Meeting of Joint Working Group on Feeding the Army, FT Lee, VA, 19 Jul 1988.

David D. Schnakenberg, COL, MS - Attend meeting at HQs, USAMRDC on FY88-89 budget execution issues, FT Detrick, MD, 3 Aug 1988.

David D. Schnakenberg, COL, MS - Represent DoD at Institute of Food Technologists Workshop on Food Research Priorities, Washington, DC, 25 Oct 1988.

David D. Schnakenberg, COL, MS - Attend briefing by Dr. Roger Hubbard on problems in maintaining hydration in MOPP at General Officer Medical-Chemical Defense Review Meeting No. 5, FT McClellan, AL, 29 Nov 1988.

David D. Schnakenberg, COL, MS - Perform site visit to plan a joint LSU/Army nutrition project at FT Polk, LA, 9 Dec 1988.

David D. Schnakenberg, COL, MS - Attend NAS/NRC Committee on Military Nutrition Research meeting at Pennington Biomedical Research Center, LSU, Baton Rouge, LA, 12-13 Dec 1988.

OFFICE OF THE COMMANDER

SIGNIFICANT VISITORS:

LTG Jimmy Ross, the DCSLOG, and COL Fitzpatrick, DALO-TST, HQDA, 12 Jan 1988.

Surg. Cmdr E. Howard Oakley, Institute of Naval Medicine, Gosport, United Kingdom, 4 Mar 1988.

Cmdr. T.L. Myette, Canadian Forces Medical Liasison Officer, Washington, DC, 14 Apr 1988.

Dr. Chris Raymond, Associate Editor, J. American Medical Association, 26 Apr 1988.

Dr. William Pryor, Acting Director, Pennington Biomedical Research Center, LSU, Baton Rouge, LA, 27 Apr 1988.

LTC David Friedman, LTC Zelig Tuchner, Dr. Aharon Levy and Dr. Zeev Tashma, Israeli Defence Forces, 15 Jul 1988.

COL Roy Sedge, III, LTC James Jaeger, Ms. Dana Colby, USAMRDC Research Area Director Systems Health Hazards Research, 15-16 Sep 1988.

Dr.Evan Senior Staff Medical Officer, Norwegian Air Force, 19 Sep 1988.

Brigadier Robin Grist, Military Attache, British Embassy, Washington, DC, 21 Sep 1988.

COL Roy Swift, Chief, Occuptational Therapy Branch, AMSC, OTSG, Falls Church, VA, 29 Sep 1988.

GEN(Ret.) Robert Sennewald, Chairman Army Food 2000 Task Force and Mr.Chester Kowalczyk, DALO-TST, 27 Oct 1988.

COL Yu Zhen Jun, Director, General Logistics Division (GLD), COL Huang Zhi Xue, GLD, COL Wang Xi Ting, Deputy Director, Quartermaster Equipment Research Institute (QERI), Dr. Wu De Yuang, Food Laboratory, QERI, Mr. Ling Tiande, Food and Uniforms, QERI and CPT Xu Zhao, Foreign Affairs Bureau, GLD, Peoples Republic Army, Beijing, Peoples Republic of China, 25 Oct - 2 Nov 1988.

Mr. Louis Cabot, Member of Secretary of Defense Commission on Base Realignment, 7 Dec 1988

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SIGNIFICANT EVENTS:

Hosted USARIEM "Current Concepts in Environmental Medicine" course. 16-20 May 1988 (25 attendees)

Assignment of MAJ John Edwards, Ph.D., Catering Corps, British Army as Special Projects Officer to Military Nutrition Division for a 2 year period beginning May 1988.

Hosted WRAIR Military Medical Science Fellows, 1-2 Sep 1988 (5 attendees)

Hosted NAS/NRC Committee on Military Nutrition Research meeting, 9 Sep 1988.

Continued Chronology on Funding and Manpower for Nutrition Research:

14 Jan 1988 - USARIEM received Manpower Voucher No 2-88, which allocated the 13 civilian authorizations for the Nutrition Division and 5 military (4 officers, 1 enlisted) were provided as directed military overstrength for FY88 only, with the military authorizations projected for FY89.

17 Feb 1988 - COL Schnakenberg, Cmdr, USARIEM, received guidance from MG Russell, USAMRDC, providing authority to immediately begin hiring permanent employees for 5 of the 13 civilian authorizations in the Military Nutrition Division. MG Russell also committed to provide sufficient resources to maintain the current (FY 88) in-house nutrition effort for next few years with out-year support to depend on resolution of negotiations on the Congressionally directed $3.5M military nutrition research project at Louisiana State University.

12 Mar 1988 - Informed by HQDA by that the Joint DCSLOG/USARIEM funding initiative (MDEP 4SOK) for the CSA,VCSA, and DUSA(OR) directive to The Surgeon General to establish an annual program for Field Ration Testing under extreme climatic conditions was funded in the FY90-94 POM for $595K in FY90 and $700K/year for FY91-94.

6 Apr 1988 - Informed by HQs, USAMRDC, that USARIEM had 4 hours to identify, by paragraph and line number of our TDA, three civilian and two military officer authorisations for decrement by end of FY88. Faced with no viable alternatives, the three civilian spaces were taken from the Military Nutrition Division and the officer slots were taken from the Research Support Division (Info Mgmt, 67D) and Heat Research Division (Physiologist, 68J)

13 May 1988 - Informed by memo from Chief of Staff, USAMRDC, that because of uncertainties regarding funding for Nutrition, a moratorium on hiring permanent employees for this program would be in place until further notice. Moratorium did not preclude hiring temporary employees against vacant authorization if funds were available.

24 Oct 88 - Received manpower voucher 3-89, from USAMRDC decrementing USARIEM 3 civilian (Mil Nutr Div) and 2 officer (67D & 68J) authorizations.

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PROFESSIONAL APPOINTMENTS/ACTIVITIES:

David D. Schnakenberg, COL, MS, Ph.D. - Chairman, NATO Panel VIII, Research Study Group 8 - Nutritional Aspects of Military Feeding.

David D. Schakenberg, COL, MS, Ph.D. - DoD Representative to Interagency Committte on Human Nutrition Research.

David D. Schnakenberg, COL, MS, Ph.D. - DoD Representative to Interagency Committee on Nutritional Monitoring.

David D.Schnakenberg, COL, MS, Ph.D. - Member, Joint Working Group on Feeding the Army.

David D. Schnakenberg, COL, MS, Ph.D. - Alternate OTSG representative, HQDA Army Food 2000 Task Force.

David D. Schnakenberg, COL, MS, Ph.D. - Member, DoD Nutrition Committee.

ALTITUDE RESEARCH DIVISION

SIGNIFICANT RESEARCH FINDINGS/DEVELOPMENTS:

State-of-the-art stable isotope and ambulatory monitoring techniques were used to study 23 Marines during a physically demanding 11-day cold weather field training exercise at 2600 meters elevation. The mean energy expenditure of the Marines as measured by the doubly labeled water method was 4800 kcal/day, while ration intake was 3100 kcal/day and body energy stores contributed 1700 kcal/day. During the first four days of the experiment the Marines exercised heavily, expending 6900 kcal/day. They were active 17.9 h/day with a mean active energy expenditure of 390 kcal/hour. This was approximately 87% of the mean maximum rate of energy expenditure measured by portable respirometer in soldiers performing short duration combat type activities. These quantitative data on energy expenditure and activity patterns during a demanding field training exercise provide unique, useful insights into the energy expenditure and fuel requirements of the soldier. For example, since predominantly body fat fuel reserves are used to meet the energy deficit of these soldiers, the overall fuel mix burned tended to be high in fat. The contribution of energy from body fat stores to meet the fuel needs of the soldier should be factored into the design of rations. In addition, hourly rates of sustained energy expenditure can be used to estimate the practical work limits of soldiers in a demanding, environmentally stressful situation.

A laboratory study was carried out to determine whether dietary lipid level influence the physiology or endurance exercise performance of soldiers. Model Nutritional Sustainment Module (NSM) rations were tested that had similar levels of carbohydrate and protein but either a high or a low lipid and total calorie content. The subjects consumed either a high lipid/3300 kcal diet or a low lipid/2300 kcal diet during a four day program of regular moderate exercise resulting in an energy expenditure of 4000 kcal/day. On the fifth day the subjects were tested for endurance exercise capacity. Nutrient intakes and physiological status of the test subjects were also assessed. The results suggest that increasing the fat content and caloric density of test rations has little effect on either the physiologic function or physical performance of soldiers over a five day period of moderate exercise. There appears to be no nutritional advantage for the short-term use of a high-fat diet by physically active soldiers. Limiting the fat content of field rations intended for short-term use to 100 grams per day would benefit the soldier by reducing ration weight or the increasing the space available for carbohydrates.

ALTITUDE RESEARCH DIVISION

SIGNIFICANT RESEARCH FINDINGS/DEVELOPMENTS:

Fluid volume distribution was studied in goats at sea level (SL) and after 16 days of hypobaric hypoxia (380 Torr, 5500 m). Total body water, plasma volume, and intracellular fluid volume all decreased significantly, while interstitial fluid volume increased significantly. The pattern of losses from both the intracellular and plasma compartments appears to be associated with an increase in interstitial fluid volume, in contrast to previous studies where increased cell water was reported due to inaccurate measurements of extracellular volume.

To determine whether alterations occurred in fine motor function in humans during acute hypoxic exposure, a prototype computerized device was developed to test 14 soldiers exposed for 30 h to a simulated altitude of 4600 m. Subjects becoming moderately ill with acute mountain sickness also demonstrated reduced upper extremity fine motor function at a level of 20-32% of sea level. Data indicated that significant changes occurred in velocity, acceleration, and deceleration rather than accuracy related variables. The study suggests that acute hypoxia impacts more on speed of motor performance rather than accuracy and that these changes can be accurately measured by a computer-driven motor function test.

Eight male soldiers were administered caffeine (4 mg/kg) or placebo in a double-blind, crossover study to determine if caffeine would increase endurance time to exhaustion (ETX; at 80% VO_2 max) during exposure to 4300 m altitude. Oxygen uptake, cardiac output, plasma levels of free fatty acids, glucose, and lactate were measured as well as perceived exertion and dietary intake. Determinations were made before and during each exercise bout at sea level and after one-hour and three-week's exposure. Submaximal ETX was not altered at sea level but was increased by 54% and 24% after one hour and three weeks at altitude, respectively. The improvements in ETX were found not to be related to the caffeine-induced increases in plasma concentrations of free fatty acids, glucose, and lactate, or reductions in perceived exertion. Dietary or cardiac output changes also could not account for the improvements. However, increases in tidal volume and minute ventilation with caffeine administration were found which suggest an increase in alveolar and arterial O_2 tension and a reduction the altitude-induced arterial hemoglobin desaturation. These changes could result in the ETX improvement observed at altitude and imply that submaximal physical performance could easily be enhanced with the simple addition of dietary caffeine.

ALTITUDE RESEARCH DIVISION

SIGNIFICANT RESEARCH FINDINGS/DEVELOPMENTS:

To test the hypothesis that chronic altitude exposure impairs arginine vasopressin, a potent natural osmoregulator, seven subjects underwent a water deprivation test at sea level, during acute exposure to 4300 m altitude, and after 20-days exposure. Although weight losses were similar in all three conditions, subjects' plasma were significantly more hypertonic during both altitude phases with no corresponding changes in plasma vasopressin levels. However, vasopressin-osmolality regression curves derived from the water deprivation test indicated a progressive increase in the threshold and slope in response to hypertonicity. In contrast to earlier findings, these data indicate that the sensitivity of the response of vasopressin secretion to hypoxia is increased rather than diminished. This has strong implications in osmoregulation and water balance at altitude as well as in the etiology of acute mountain sickness.

Lowering the oxygen concentration of air at sea-level pressure from 21% to 17% (partial pressure O_2 = 129 torr) for three days reduced combustion rates in confined spaces 20-40% but did not induce any meaningful symptoms of acute mountain sickness in 13 young male volunteers. Reducing the O_2 concentration even further to 13% (partial pressure = 99 torr) induced moderate to severe illness in 5 individuals after 17 hours; 2 of these remained sick for the next 48 hours. Blood O_2 saturation levels dropped from 98 to 92% in 13%O_2, but there was no relationship between saturation levels and presence or absence of illness. Reducing the atmospheric pressure of 17% O_2 air for 7.5 hours to produce an O_2 partial pressure of 99 torr induced mild illness in 2 individuals. This study indicates that 17% O_2 air is a useful method for increasing fire safety in confined spaces without significant illness, but 13% O_2 is not.

PUBLICATIONS:

Bender, P.R., B.M. Groves, R.E. McCullough, R.G. McCullough, S.Y. Huang, A. J. Hamilton, P.D. Wagner, A. Cymerman and J.T. Reeves. Oxygen transport to exercising leg in chronic hypoxia. J. Appl. Physiol. 65:2592-2597, 1988.

Burse, R.L. and V.A. Forte. Acute mountain sickness at 4500 m is not altered by repeated eight-hour exposures to 3200-3550 m normobaric hypoxic equivalent. Aviat. Space Environ. Med. 59:942-949, 1988.

Devine, J.A. and A. Cymerman. A rodent water dispensing system for use in hypobaric chambers. Lab. Animal Sci. 38:210-212, 1988.

ALTITUDE RESEARCH DIVISION

PUBLICATIONS:

Forte, V.A., J.A. Devine and A. Cymerman. Research stanchion and transporter for small ruminants. USARIEM Technical Report No. T13/88, 1988.

Forte, V.A., J.A. Devine and A. Cymerman. Research stanchion and transporter for small ruminants. Lab. Anim. Sci. 38:478-481, 1988.

Fulco, C.S., P. B. Rock, L. A. Trad, V. Forte, Jr., and A. Cymerman. Maximal cardiorespiratory responses to one- and two-legged cycling during acute and long-term exposure to 4300 m. Eur. J. Appl. Physiol. 57(6):761-766, 1988.

Fulco, C.S. Human acclimatization and physical performance at high altitude. J. Appl. Sport Science Res. 2:79-84, 1988.

Fulco, C.S. and A. Cymerman. Human Performance and Acute Hypoxia. In: Human Performance Physiology and Environmental Medicine at Terrestrial Extremes. K.B. Pandolf, M.N. Sawka, and R.R. Gonzalez (Ed.), Benchmark Press, Indianapolis, 1988, pp. 467-495.

Groves, B.M., J.T. Reeves, J.R. Sutton, P.D. Wagner, A. Cymerman, M.K. Malconian, P.B. Rock, P.M. Young and C.S. Houston. Pulmonary hemodynamics with prolonged hypoxia. In: Hypoxia: The Tolerable Limits. J.R. Sutton, C.S. Houston, and G. Coates (Eds.). Benchmark Press, Indianapolis, 1988, pp. 181-193.

Hoyt, R.W. Nutritional implications of high tech food - should combat rations be high or low fat?. Activities Report of the R&D Associates 40:51-56, 1988.

Iwanyk, E.J. Clinical Flight Medicine - Visual Testing. In: U.S. Army Aviation Handbook. S. Arny (Ed.). U.S. Army, Ft. Rucker, 1988, pp. D53-D67.

Johnson, T. S., P.B. Rock, J.B. Young, C.S. Fulco, and L.A. Trad. Hemodynamic and sympathoadrenal responses to altitude in humans: effect of dexamethasone. Aviat. Space Environ. Med. 59:208-212, 1988.

Kobrick, J.L., E. Cronin, B. Shukitt, C.S. Houston, J.R. Sutton and A. Cymerman. Operation Everest II: lack of an effect of extreme altitude on visual contrast sensitivity. Aviat. Space Environ. Med. 59:160-164, 1988.

Kraemer, W.J., P.B. Rock, C.S. Fulco, S.E. Gordon, J.P. Bonner, C.D. Cruthirds, L. Marchitelli, L. Trad and A. Cymerman. Influence of altitude and caffeine during rest and exercise on plasma levels of proenkephalin peptide F. Peptides 9:1115-1119, 1988.

ALTITUDE RESEARCH DIVISION

PUBLICATIONS:

Reeves, J.T., B.M. Groves, P.D. Wagner, A. Cymerman, P.M. Young, P.B. Rock, M.K. Malconian, J.R. Sutton, H. Green, and C.S. Houston. Operation Everest II: Maintained muscle energy stores during exercise at extreme altitude. In: High-altitude Medical Science. G. Ueda (Ed.). Shinshu University, Matsumoto, Japan, 1988, pp. 3-12.

Rose, M.S., C.S. Houston, C.S. Fulco, G. Coates, J.R. Sutton and A. Cymerman. Operation Everest II: nutrition and body composition. J. Appl. Physiol. 65:2545-2551, 1988.

Shukitt, B.L., R.L. Burse, L.E. Bandaret, D.R. Knight, and A. Cymerman. Cognitive performance, mood states, and altitude symptomatology in 13-21% oxygen environments. USARIEM Technical Report T/18, 1988.

Sutton, J.R., J.T. Reeves, P.D. Wagner, B.M. Groves, A. Cymerman, M.K. Malconian, P.B. Rock, P.M. Young, S.D. Walter and C.S. Houston. Operation Everest II: oxygen transport during exercise at extreme simulated altitude. J. Appl. Physiol. 64:1309-1321, 1988.

Sutton, J.R., J.T. Reeves, B.M. Groves, P.D. Wagner, A. Cymerman, P.M. Young, M.K. Malconian, P.B. Rock, and C.S. Houston. Exercise at extreme altitude. In: Nerve and Muscle: Factors Affecting Motor Performance. P. Russo and R. Balnave (Eds.). Cumberland College Press, Sydney, 1988, pp. 113-119.

Sutton, J.R., C.S. Houston, and A. Cymerman. Limitations to performance at extreme altitude. In: Nerve and Muscle: Factors Affecting Motor Performance. P. Russo and R. Balnave (Eds.). Cumberland College Press, Sydney, 1988, pp. 133-139.

Sutton, J.R., J.T. Reeves, P.D. Wagner, B.M. Groves, A. Cymerman, M.K. Malconian, P.B. Rock, P.M. Young and C.S. Houston. Tolerable limits of hypoxia for the lungs: oxygen transport. In: Hypoxia: The Tolerable Limits. J.R. Sutton, C.S. Houston, and G. Coates (Eds.). Benchmark Press, Indianapolis, 1988, pp. 194-199.

ABSTRACTS:

Bender, B.M., R.E. McCullough, R.G. McCullough, S.Y. Huang, A.J. Hamilton, P.D. Wagner, A. Cymerman and J.T. Reeves. Chronic hypoxia increases arterial O_2 content and decreases exercise leg blood flow. Fed. Proc. 2:A1282, 1988.

ALTITUDE RESEARCH DIVISION

ABSTRACTS:

Burse, R.L., C.S. Fulco, A. Cymerman, and D.R. Knight. Altitude illness symptomatology in 13, 17, and 21% oxygen environments. Proc. 30th Ann. Mtg. Mil. Testing Assoc., Washington, D.C., November, 1988.

Forte, V.A., Jr.,D.E. Leith and A. Cymerman. Ventilatory endurance at altitude. Fed. Proc. 2:A1720, 1988.

Fulco. C.S., A. Cymerman, J.T. Reeves, P.B. Rock, L. Trad and P.M. Young. Propranolol does not increases the incidence or severity of acute mountain sickness (AMS) in young males. Fed. Proc. 2:A1720, 1988.

Hoyt, R.W., M.J. Durkot, V. Pease, O. Martinez, V. Forte, Jr., L. Trad and A. Cymerman. Fluid volume distribution in goats exposed for 16 days to hypobaric hypoxia. Fed. Proc. 2:A1720, 1988.

Luria, S.M., N. Norris, and A. Cymerman. Visual sensitivities under reduced oxygen. Military Testing Association, Washington, D.C., November, 1988.

Schlichting, C.L., D.R. Knight, and A. Cymerman. Cognitive and motor performance under reduced oxygen. Military Testing Association, Washington, D.C., November, 1988.

Young, P.M., A.J. Young, R.G. McCullough, L.G. Moore, A. Cymerman and J.T. Reeves. Propranolol effects on plasma metabolite responses to exercise at high altitude. Fed. Proc. 2:A1282, 1988.

PRESENTATIONS

Burse, R.L. Altitude acclimatization. Current Concepts in Environmental Medicine, WRAIR Medical Fellows, USARIEM, May, 1988.

Burse, R.L. Testing vision, performance, and subjective symptomatology in reduced oxygen environments. 30th Annual Meeting of the Military Testing Association, Arlington, VA, November, 1988.

Iwanyk, E. Medical problems at high altitude. Current Concepts in Environmental Medicne, WRAIR Medical Fellows, USARIEM, May, 1988.

Hamilton, A.J. Alterations on motor function in soldiers during acute high altitude exposure. 1988 Uniformed Services University Surgical Associates Day, Bethesda, MD, April, 1988.

ALTITUDE RESEARCH DIVISION

KEY BRIEFINGS:

Hoyt, R.W. Acute physiological responses to high altitude. Current Concepts in Environmental Medicine, WRAIR Medical Fellows, USARIEM, May, 1988.

Hoyt, R.W. Nutritional implications of high tech food - should combat rations be high or low fat?, Research and Development Associates, NRDEC, Natick, MA, October, 1988.

Hoyt, R.W., Ph.D. Energy balance and nutrition during a high altitude cold operation. Marine Corps Mountain Warfare Training Center, Bridgeport, CA, 1988.

Cymerman, A., Ph.D. Medical problems at high altitude. Army Flight Surgeons Course, U.S. Army School of Aviation Medicine, Ft. Rucker, 1988.

Iwanyk, E., MAJ. Medical problems at high terrestrial elevations. Northern Warfare Training Center, Fort Greely, Alaska, 1988.

Hoyt, R.W., Ph.D. Medical problems at high altitude. Army Flight Surgeons Course, U.S. Army School of Aviation Medicine, Ft. Rucker, 1988.

Cymerman, A., Ph.D. Physical and psychological performance upon arrival at 6000 ft altitude in a military population. Office of the Division Surgeon, MAJ Lester Martinez, 4th Mechanized Infantry, Ft. Carson, CO, 1988.

Iwanyk, E., MAJ. Doctor N. S. Roy, Indian Army physician associated with the joint Indian and United States Army expedition to Mana Peak. Treatment and prevention of altitude related illnesses. New Delhi, India, 1988.

Cymerman, A., Ph.D. Dr. Richard Traugott, Brooks Air Force Base, Medical and Logistical Problems at altitude in Bolivia, 1988.

MAJ Eugene Iwanyk. Medical problems at high terrestrial elevations. United States Embassy, New Delhi, India, 1988.

Hoyt, R.W., Ph.D. Testing Rations Under Cold Weather, High Altitude Conditions. Delegation from General Logistics Department, Peoples Liberation Army, Peoples Republic of China, 1988.

Hoyt, R.W., Ph.D. Medical problems at high altitude. Army Flight Surgeons Course, U.S. Army School of Aviation Medicine, Ft. Rucker, November, 1988.

ALTITUDE RESEARCH DIVISION

KEY BRIEFINGS:

Hoyt, R.W., Ph.D. High altitude illness prophylaxis. Marine Corps Mountain Warfare Training Center, Bridgeport, CA, 1988

Hoyt, R.W., Ph.D. Field measurement of energy expenditure. First Special Forces Group (Airborne), Operational Detachment 155, B Co, 2nd Bn, Ft. Lewis, WA, 1988.

SIGNIFICANT TDY

Cymerman, A., Ph.D., A. Hamilton, M.D., and Ms. L. Trad. Collaboration and consultation on retinal digital image analysis. NASA, Houston, TX, January, 1988.

Cymerman, A., Ph.D. Contract site visit to Denali Medical Aid Station (DAMD17-88-C-8121 and participation in USARIEM/Altitude Field Study AR3-88. Mt. McKinley, AK, April, 1988.

Iwanyk, E., MAJ. Participation as team physician in a joint American-Indian Army operation to ascend to the summit of Mana Peak, India (23,860 ft.), India, August - October, 1988.

Cymerman, A., Ph.D. Contract site visit and participation in joint American-Chinese-Tibetan medical research study of resident high altitude populations supported by DAMD17-87-C-7202. Lhasa, Tibet, October - November, 1988.

Devine, J.A., M.E. Instruction in the theory an use of hypobaric chambers. Department of Oral Biology/Physiology, Medical College of Georgia. Augusta, GA, November, 1988.

SIGNIFICANT VISITORS

Dr. Simon Chasdi, Profesor, Harvard University, Cambridge, MA, March, 1988.

Dr. David Leith, Kansas State University, Dept. of Surgery Small Animal Branch, Manhattan, Kansas, April, 1988.

Mr. Courtney Skinner, expedition and team leader, Wyoming Centennial Everest Expedition, June, 1988.

ALTITUDE RESEARCH DIVISION

SIGNIFICANT VISITORS

CPT Timothy J. McCormick, USAF, Harvard School of Public Health. The effects of hypoxia and hypobaria on human performance and treatment modalities for altitude related illnesses, June, 1988.

LTC Terence J. Lyons, USAF, Harvard School of Public Health. The effects of hypoxia and hypobaria on human performance and treatment modalities for altitude related illnesses. June, 1988.

CPT David W. Levine, M.D. Tenth Special Forces. Ft.Devens, MA. Recommendations on prevention and treatment of altitude related illnesses on an exercise in the Rocky Mountains, December, 1988.

PROFESSIONAL APPOINTMENTS/ACTIVITIES

MAJ Eugene Iwanyk. Aviation medical officer for the 94th ARCOM Aviation Support Facility (64) at Ft. Devens, MA and MA National Guard.

COLD RESEARCH DIVISION

SIGNIFICANT RESEARCH FINDINGS/DEVELOPMENTS:

The peripheral vasodilator Buflomedil (Abbott Laboratories) was delivered, in solution with dimethyl sulfoxide (DMSO), directly to the site of injury in an animal model for frostbite. In four groups of anesthetized rats, left hindpaws were cooled to freezing, as indicated by heat of fusion; cooling continued until the footpads reached -15°C. Hindpaws of all groups were rewarmed in a 40°C bath. During rewarm those from group one were immersed in 30% DMSO, from group two in 24mg buflomedil in 30% DMSO, from group three in deionized water and from group four in 24mg buflomedil in deionized water. Right hindpaws were neither cooled nor rewarmed; they served as controls. Vascular microcorrosion casts were made from left and right hindpaws of all groups. Systemic distribution of the drug was indicated by the significant difference in cast weights of uninjured hindpaws in group two when compared with cast weights of uninjured hindpaws from the three other groups. However, cast weights of frozen hindpaws from all groups were not significantly different from each other, suggesting that, in an acute model, this mode of therapy does not improve vascular patency.

Amiloride, a sodium channel antagonist used to reduce reflow injury to the ischemic heart muscle, augmented rather than improved mitochondrial lesions in diaphragm and lethality with pyridostigmine treatment in rats given 3.6mg Mestinon/kg. When a weight matched group of older rats (536g, 6-8 months old) were compared to a younger group of similar weight (500g, 4 months old), the latter group was more sensitive to pyridostigmine than the former. This suggested that both younger (220g, 2 months old) and older, retired breeders (536g, 6-8 months old) were less sensitive to pyridostigmine than 500g (4 month old) sedentary rats. In acute studies of Ms. Mathew with physostigmine treated rats run to exhaustion, typical mitochondrial lesions at neuromuscular junctions were observed in rats given 200ug/kg, while no typical lesions were found with the acute dose of 100ug/kg. Typical mitochondrial lesions were observed in diaphragms of rats treated for one week with 125ug/hr, but not in the group treated for two weeks with 125ug/hr although some had swollen mitochondria in areas unrelated to neuromuscular junctions.

The effect of race and geographic origin on the ability to maintain hand temperature was tested on 48 individuals from Minnesota and Alabama during a cold stress test (hand dip in 40 degree Fahrenheit water for 20 minutes). After studying 12 Blacks and 12 Whites from Alabama and 12 Blacks and 12 Whites from Minnesota it was found that White subjects demonstrated the highest hand temperatures both during and after removal from the cold water than the group of Blacks. The White group from Alabama showed warmer hands overall compared to the other groups; an unexpected finding. The Alabama

COLD RESEARCH DIVISION

SIGNIFICANT RESEARCH FINDINGS/DEVELOPMENTS:

group of Whites included younger and more physically active individuals than the other groups which may partly explain the contradictory results for the origin effect.

A second treatment of previously treated Raynaud's patients by classical conditioning is possible, but the effectiveness depends on the degree of decline from the initial treatment.

Augmented blood vessel permeability and platelet aggregation can be features associated with hypothermia. Endothelial cells that compose the interior wall of blood vessels significantly influence platelet activity and permeability. Their production of prostacyclin regulates platelet activity and augments endothelial cell barrier function. Exposure of vascular endothelial cells to cold reduces their ability to prevent platelet aggregation, which is relevant to a disturbance in prostacyclin metabolism. Thus, alterations in prostacyclin production may partially explain circulatory problems associated with hypothermia. Understanding the cellular mechanisms that influence prostacyclin synthesis is essential to the development of methods to regulate its release during cold exposure. Using a newly developed spectrophotoflurometric assay for cellular F-actin, a correlation between bradykinin-stimulated prostacyclin production and actin stress fiber density has been demonstrated. This finding in conjunction with those that suggest regulation of the rate limiting enzyme of the prostacyclin cascade by actin and the enhancement of actin stress fiber formation by prostacyclin indicates a reciprocal loop for the control of both prostacyclin metabolism and stress fiber density within endothelial cells.

Animal and human studies suggest a relationship between plasma fibronectin level and tolerance to heat stress. To further define this relationship, plasma fibronectin levels were studied in users of tobacco products and in former heatstroke patients. Findings indicated that consumption of tobacco had no adverse effect on plasma fibronectin levels. Subjection of prior heatstroke victims to a heat acclimation program did not result in an enhancement of their plasma fibronectin values. This was in contrast to an earlier study that demonstrated that such acclimation programs do significantly augment plasma fibronectin in normal subjects. Since the use of tobacco products is considered a cardiovascular risk factor and might, therefore, also correlate with reduced heat tolerance, the finding of no effect of tobacco use on plasma fibronectin level indicated that concentration of this protein may not correlate with all potential predisposing factors of reduced thermotolerance. However, the inability of heatstroke victims to

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SIGNIFICANT RESEARCH FINDINGS/DEVELOPMENTS:

augment their plasma fibronectin levels after heat acclimation procedures may indicate that this can be used to determine the presence of some continuing malfunction after heat stress injury.

A microswine model was developed for arterial and venous catheterization using the Vascular Access Port. This model has ben used in altitude metabolism studies. Tritiated water, C-14 insulin, and Indocyanine Green were used to measure total body water, extracellular fluid, and plasma volume at 15,000 feet over a three week period. Stable isotopes of glycerol and palmitate were employed to study fat metabolism and oxidation. In addition, hepatic capacity to clear caffeine levels in the blood was also studied. Data from these studies is being used to formulate future work in humans. The microswine model will be used to develop a method for studying acute fluid shifts in passively dehydrated swine. This will be accomplished by adapting methods currently applied to measure volume shifts in chronic dehydration studies.

The ability to passively rewarm a cold stressed foot was measured in recovered trench foot (TF) patients approximately six years post injury. Two groups of Argentine subjects, one of thirty-four men diagnosed as having suffered TF during the Falkland Islands conflict and the other of fifteen uninjured active duty male soldiers, were stressed by cold water immersion of 10°C for ten minutes. Infrared thermographic images were recorded prior to the cold water immersion (baseline), immediately upon exiting the water bath (T=0) and at one minute intervals for the following twenty minutes (T=20). The digitized images were analyzed to determine mean temperatures for three areas: the great toe, the four other toes, and all five toes together. These groupings were statistically compared from T=0 to T=20, the area under the rewarming curve (AURC), and no significant difference was seen at the $p<0.05$ level. All subjects were also separated within their groups based on their ability to rewarm to pre-immersion temperature; the AURCs of the subgroupings were then statistically compared. Five controls (Good Rewarming Controls or GRC) showed a statistically significant ($p<0.01$) difference of means when compared to the remainder of the controls (Poor Rewarming Controls/PRC) and the injured group. No difference was noted at the $p<0.05$ level between the PRCs and the TF injured subjects. The two possible conclusions to be drawn are that either 1) the injury caused the uniform poor rewarming ability or 2) the injured subjects are part of a cold injury susceptible subset of the population.

The question of whether dehydration plays a role in the production of cold injury was addressed by looking at hand cooling rates after dehydration and subsequent re-hydration. Ten men were dehydrated by restriction of fluid intake and by exercise over two and a half days (weight loss = 4.6%). Body

COLD RESEARCH DIVISION

SIGNIFICANT RESEARCH FINDINGS/DEVELOPMENTS:

weight returned to -1.6% within ten hours after re-hydration suggesting the weight loss was fluid loss. Measures of blood and urine constituents also were indicative of dehydration. These subjects experienced a cold test prior to and after dehydration and after rehydration. The fingers, but not the backs of the hands, of the dehydrated group were significantly colder following dehydration. A group of ten control subjects tested under identical conditions, but hydrated at all times, showed no changes. Dehydration of 4.4% produced 18% cooler hands which could have significant impact on the production of cold injury. It is advisable to maintain hydration to prevent peripheral cold injuries.

PUBLICATIONS:

Dubill, P.M., N.W. Ahle, M.W. Sharp, R.A. Mariano, F.H. Broski, and S.J. Engler. Use of Electrical Impedance to Assess Frostbite Injury Severity in a Swine. USABRDL Technical Report No. 8811, 1988.

DuBose, D.A., M. Lukason, R. Mariano, R. Harris, and G. Silver. Ketanserin modulates rabbit foot cooling in the presence or absence of exogenous serotonin. Cryobiology 25:233-237, 1988.

Foutch, R.G. and W. Hendrichs. Carbon Monoxide Poisoning At High Altitudes. Am. J. of Emerg. Med. 6(6):596-8. 1988.

Hamlet, M.P. Cold Injury. In: Emergency War Surgery Nato Handbook. Thomas E. Bowen, M.D. (BG, MS, USA) (Ed.). U. S. Gov't Printing Office, Wash., DC, 1988, pp. 57-73.

Hamlet, M.P. Human Cold Injuries. In: Human Performance Physiology and Environmental Medicine at Terrestrial Extremes. K.B. Pandolf, M.N. Sawka, and R.R. Gonzalez Ed.). Benchmark Press Inc. pp. 435-466, 1988.

Hamlet, M.P., Pozos, R.S., and Danzl, D.F. Hypothermia. In: Management of Wilderness Environmental Emergencies. Auerbach and Geehr. (Ed.), pp. 35-76, 1988.

Hamlet, M.P. Cold Weather Training SOP. In: Ranger Department Handbook SOP for the Training Brigade-Hot and Cold Weather Training. February 1988.

Hamlet, M.P. Cold Injuries. In: TG No. 172. 1988.

Roberts, D.E. and J.J. Berberich. The Role of Hydration on Peripheral Response to Cold. Mil. Med. 153:605-608, 1988.

COLD RESEARCH DIVISION

PUBLICATIONS:

Wilkerson, J. and M.P. Hamlet. Medical After Action Conference, Mount Hood, 1986, Bypass Rewarming. USARIEM Technical Report No. T10-88, 1988.

ABSTRACTS:

Bandick, N.R., M. Williams, K.J. Clark, and D.E. Roberts. The Influence of Vascular Smooth Muscle Contraction on the Visoelastic Properties of the Arterial Wall. The Physiologist 31(4):A138, 1988.

Bowers, W.D., M. Blaha, I. Morales, and P. Daum. Mestinon (PYR) Induced Alterations in Rats: Impact of Fixation, Nifedipine and Body Weight. FASEB J. 2:A825, 1988.

Daum, P., W. Bowers, Jr., J. Tejada, and D. Morehouse. The Effect of the Direct Delivery of Buflomedil to the Site of Frostbite Injury. FASEB J. 2:A1529, 1988.

DuBose, D.A., D. Shepro, and H.B. Hechtman. Changes in endothelial cell rhodamine phalloidin binding and prostacyclin production after bradykinin exposure. FASEB J. 2(60):A1863, 1988.

DuBose, D.A., R. Carpenter, J. Guzman, and R. Haugland. In vitro and in situ observations of the endothelial cell F- and G-actin cytoskeleton. FASEB J. 2(4):A419, 1988.

Roberts, D.E., D.L. Kerr, and W. Beethan. The Efficacy of a Second Treatment (Classical Conditioning) on Raynaud's Syndrome. FASEB J. 2(5):A1529, 1988.

PRESENTATIONS:

Daum, P.S. An Assessment of the Ability of the Peripheral Vasodilator Buflomedil to Increase the Amount of Microvasculature Retained After Freeze Injury. Second Annual East Coast Conference on Thermal Regulation, Bethesda, MD, June 1988.

DuBose, D.A. Influence of endothelial cell metabolism on cardiovascular function. Biological Science Center, Boston University, Boston, MA. November 1988.

COLD RESEARCH DIVISION

KEY BRIEFINGS:

Neil W. Ahle, CPT, VC. Cold Weather Injury Prevention; AT&T Linemen Meetings (9 lectures throughout MA), January 1988.

Neil W. Ahle, CPT, VC and Mark W. Sharp, SSG. Results of Infrared Study. To COL Eugene Boreley, Army Attache, Argentina, February 1988.

Neil W. Ahle, CPT, VC and Mark W. Sharp, SSG. Conduct of Infrared Study. To BG Jorge Marera, Cdr of Health, Army of Argentina. Buenos Aires, Argentina, February 1988.

Neil W. Ahle, CPT, VC. Cold Weather Injury Prevention; Ft. Leonard Wood, MO, January 1988.

Neil W. Ahle, CPT, VC. Results of HURC #309 (Argentine Trenchfoot Study). To RAD III Briefing, USARIEM, Natick, MA, September 1988.

Neil W. Ahle, CPT, VC, and Mark W. Sharp, SSG. Infrared Thermography Briefing for U. S. Army and Norwegian Air Force Physicians, USARIEM, Natick, MA, September 1988.

Neil W. Ahle, CPT, VC. Cold Weather Injury Prevention; MA National Guard Units, USARIEM, MA, September 1988.
Neil W. Ahle, CPT, VC and Mark W. Sharp, SSG. Infrared Thermography Briefing for Cold Research Liaison Officer-Alaska, USARIEM, Natick, MA, October 1988.

Neil W. Ahle, CPT, VC. Cold Weather Injury Prevention; MA Snowmaker's Association, New Ashford, MA, November 1988.

Neil W. Ahle, CPT, VC. Cold Weather Injury Prevention, Cross Country and Alpine Skiers Assoc., Beverly, MA, November 1988.

Neil W. Ahle, CPT, VC. Cold Weather Injury Prevention; U. S. Army Reserve, Ft. Devens, MA, December 1988.

Neil W. Ahle, CPT, VC. Cold Weather Injury Prevention; Ft. Leonard Wood, MO, December 1988.

Patricia S. Daum, MS. Application of Vascular Microcorrosion Casting Techniques to the Evaluation of Therapeutic Drug Regimens for Cold Injury; Army Systems Hazards Research Program Review and Analysis, at the US Army Research Institute of Environmental Medicine, Natick, MA, September 1988.

DuBose, D.A., Ph.D. Effects of temperature extremes on endothelial cell cytoskeletal structure and eicosanoid metabolism. Army systems hazards research program review and analysis (USARIEM). September 1988.

COLD RESEARCH DIVISION

KEY BRIEFINGS:

Murray P. Hamlet, D.V.M. Cold Weather Operations Briefing; National Guard Commanders, Mountain Warfare Training School, Jericho, VT, January 1988.

Murray P. Hamlet, D.V.M. Cold Weather Injury Prevention Briefing; Army Flight Surgeon Course, Ft. Rucker, AL, February-March 1988.

Murray P. Hamlet, D.V.M. Cold Weather Operations Briefing; National Guard Commanders, Mountain Warfare Training School, Jericho, VT, February 1988.

Murray P. Hamlet, D.V.M. Cold Weather Operations Briefing; National Guard Commanders, Mountain Warfare Training School, Jericho, VT, March 1988.

Murray P. Hamlet, D.V.M. Cold Injury lecture at Grand Rounds, Fitzsimmons Army Medical Center, Aurora, CO, April 1988.

Murray P. Hamlet, D.V.M. Cold Weather Injury, Prevention and Treatment. Uniformed Services Academy of Family Physicians, Salt Lake City, UT, March 1988.

Murray P. Hamlet, D.V.M. Cold Weather Injury, Prevention and Treatment. 69th AES Squadron, McQuire Air Force Base, Wrightstown, NJ, July 1988.

Murray P. Hamlet, D.V.M. Cold Weather Injury Prevention Briefing; Army Flight Surgeon Course Class 88-3, Ft. Rucker, AL, August 1988.

Murray P. Hamlet, D.V.M. Cold Weather Injury Prevention Briefing; VXE-6 (Antarctic Development Squadron 6) Annual Pre-deployment Brief, Pt. Mugu, CA, September 1988.

Murray P. Hamlet, D.V.M. Recent Advances in Cold Injury Prevention. 1988 USA Preventive Medicine Physician's Short Course, Baltimore, MD, September 1988.

Murray P. Hamlet, D.V.M. Cold Weather Hazards, 1988 Orientation Conference for Antarctic Personnel, National Science Foundation, Arlington, VA, September 1988.

Murray P. Hamlet, D.V.M. To consult on cold injury cases and present Medical Grand Rounds to internists and medical sub-specialists on Raynaud's and cold induced injuries, Walter Reed Army Medical Center, Washington, DC, October 1988.

Murray P. Hamlet, D.V.M. Environmental Medicine in Preparation for Winter Exercises. 101st Airborne Division, Ft. Campbell, KY, October 1988.

Murray P. Hamlet, D.V.M. Cold Weather Injury Prevention Briefing; Army Flight Surgeon Course Class 89-1, Ft. Rucker, AL, October 1988.

COLD RESEARCH DIVISION

KEY BRIEFINGS:

Murray P. Hamlet, D.V.M. Prevention and Management of Cold Injuries. USA Training Center, Ft. Dix, NJ, November 1988.

Ronald L. Jackson, CPT and Donald E. Roberts, Ph.D. The Effect of Race and Geographic Origin on Hand Cooling. Dept of Physiology, University of Minnesota, Duluth, Duluth, MN, June 1988.

Ronald L. Jackson, CPT. The Effect of Race and Geographic Origin on Hand Cooling. Command Staff, US Army Aeromedical Research Laboratory, Ft. Rucker, AL, August 1988.

Ronald L. Jackson, CPT. The Effect of Race and Geographic Origin on Hand Cooling. Athletic Department, Enterprise State Junior College, Enterprise, AL, August 1988.

Mark W. Sharp, SSG and Neil W. Ahle, CPT. Infrared Thermographic Procedures, Staff of Del Hospital Militar Central, Buenos Aires, Argentina, February 1988.

Mark W. Sharp, SSG. Infrared Thermography Briefing, 82d Airborne Division Staff, USARIEM, Natick, MA, August 1988.

Mark W. Sharp, SSG. Infrared Thermography Briefing, Brigadier Grist, British Army, USARIEM, Natick, MA, September 1988.

Mark W. Sharp, SSG. Infrared Thermography Briefing, Mr. Louis Cabot, SECDEF Commission on Base Realignment, USARIEM, Natick, MA, December 1988.

SIGNIFICANT TDY:

Neil W. Ahle, CPT and Mark W. Sharp, SSG. To Buenos Aires, Argentina, to collect data on the rewarming ability of trenchfoot injured Argentine Army veterans of the Falkland Islands engagement, February 1988.

Neil W. Ahle, CPT. To San Antonio, Texas for Continuing Education Conference on Emergency Medicine, September 1988.

Andre A. Darrigrand, MAJ. To attend seminar on Laboratory Animal Medicine presented by the American College of Laboratory Animal Medicine, April 1988.

Murray P. Hamlet, D.V.M. To participate in cold weather training with Ranger Units, Salt Lake City, UT, February 1988.

Murray P. Hamlet, D.V.M. To participate in the development of medical standards for the wilderness context. ASTM Wilderness EMS Task Group, Baltimore, MD, May 1988.

COLD RESEARCH DIVISION

SIGNIFICANT TDY:

Murray P. Hamlet, D.V.M. To attend Workshop on Chemical Operations in the Cold. USA Chemical RD&E Command, Aberdeen Proving Ground, MD, August 1988.

Ronald L. Jackson, CPT, Donald E. Roberts, Ph.D., Randy Cote, SPC, and Patrick McNeal, SPC. To Duluth, MN for data collection at the University of Minnesota, Duluth, Duluth, MN, August 1988.

Ronald L. Jackson, CPT, Donald E. Roberts, Ph.D., Randy Cote, SPC, and Patrick McNeal, SPC. To Alabama for data collection at Ft. Rucker, AL, September-October 1988.

Donald E. Roberts, Ph.D., D. Moore, SSG, P. McNeal, SPC. To Ft. Wainwright, AK to collect data for study on the effects of water consumption on nutrient intake, February 1988.

Donald E. Roberts, Ph.D. To Montreal, Canada to participate in The Joint Conference of the American and Canadian Physiological Societies, October 1988.

Mark W. Sharp, SSG. To Alaska to confer with Dr. William Mills on possible joint efforts toward refining the use of infrared thermography and scintigraphy in the early delineation of frostbite eschar debridement, January 1988.

SIGNIFICANT VISITORS:

BG Grist, United Kingdom, 21 September 1988.

PROFESSIONAL APPOINTMENTS/ACTIVITIES:

The Animal Care Facility was granted Full Accreditation by the American Association for the Accreditation of Animal Care.

Patricia S. Daum elected to a one year term as a Biological Science Director in the New England Society for Electron Microscopy, December 1988.

Saleh M. Rahman, Mathematics and Statistics Teacher, Lexington High School, Lexington, MA, served as 1988 Batelle Award recipient to act as statistical advisor for the Cold Research Division, 1988.

EXERCISE PHYSIOLOGY DIVISION

SIGNIFICANT RESEARCH FINDINGS/DEVELOPMENTS

A study of the epidemiology of physical training associated injuries was conducted on men undergoing 13 week one station unit infantry training at Ft. Benning, GA. Of the 303 subjects entered into the study, 139 (45.9%) suffered at least one injury resulting in a sick-call visit. These injuries resulted in 969 days of lost or modified training. One hundred twelve (37%) experienced at least one musculoskeletal injury to the lower back or lower extremities. One hundred seventy two separate musculoskeletal injuries were experienced at 147 sites. Among the Army trainees, the sites and types of injury occurrence is generally similar in rank order to that reported in other studies, both civilian and military. This indicates that injuries being experienced among military trainees are of the same nature of those being experienced by other running populations. The factors with significant risk of injury associated include age, levels of physical activity and possibly physical fitness, smoking history, and back and hamstring flexibility. Several other factors were identified which were strongly suggestive but lacked statistical significance. A self-assessed history of low overall physical activity, and performing in the lowest quartile on the diagnostic pushups test were both associated with increases in risk which approached statistical significance. A history of a previous ankle sprain was associated with an increase in risk, while a previous lower extremity injury exclusive of an ankle sprain was associated with a decrease in risk, both of which approached significance. The company of assignment was a predictor of injury, with the company running the most and marching the least having a higher incidence of injury.

The large inter-observor variability in the skinfold procedure for body fat estimation necessitated the development of an alternative method that required no formal training, could be administered by non-technical personnel and had low inter-observor variability. Circumference-based equations were developed to replace the skinfold equations. The equation selected for males was: % body fat = 46.892 - (68.678 x Log_{10} height) 76.462 x Log (abdominal circumference - neck circumference)) with a R of 0.817 and a SEE of 4.020. The selected female equation was: % BF = -35.601 - (0.515 x height) + (0.173 x hip circumference) - (1.574 x forearm circumference) - (0.533 x neck circumference) - (0.200 x wrist circumference) + (105.328 x Log_{10} weight) with a R of 0.82 and SEE of 3.598. Height and circumferences are expressed in centimeters and weight in kilograms. The equations apply to all ages and racial groups. Conversion tables were developed for easy calculation of percent body fat from the raw measurements of circumferences, height and weight. In those individuals exceeding the weight-height table, the equation

EXERCISE PHYSIOLOGY DIVISION

SIGNIFICANT RESEARCH FINDINGS/DEVELOPMENTS:

was more accurate in males in correctly classifying individuals than the weight-height table but only marginally better in women. Cross validation of the equations with an independent sample of Navy personnel resulted in a R of .89, a SEM of 3.7 and a mean difference with densitometry of 3.2% body fat units for men and a R of .79, SEM of 4.4 and a mean difference with densitometry of 0.2% body fat units for women. In addition to the ease of measurement by non-technical observers, the equations better predict % body fat measured by hydrostatic weighing than do the previously used Durnin-Womersley skinfold equations when considering all ages, racial groups and degrees of adiposity.

A study was carried out to define the physiological determinants of load bearing performance over distances from 2 to 12 km. Twenty eight soldiers, experienced in load bearing, were initially assessed for: aerobic power (VO_2max), leg strength and muscular endurance, maximal lift capacity, maximal heart rate (HRmax), body composition, body anthropometry, and submaximal treadmill response to load bearing. Following a week of fitness assessment, each soldier performed four, best effort, load bearing trials at distances of 2, 4, 8 and 12 km. All trials were scheduled in random order on four successive weeks. The total load carried (pack, weapon, and clothing) was 46.12 kg. Mean performance times for each distance were 16.0, 35.2, 77.2, and 125.0 minutes, respectively. Mean exercise intensity (% HRmax) as measured by HR telemetry for each trial was 74, 71, 69 and 63%, respectively. Correlation of fitness variables to performance times for the total group indicated no distinct physiological correlates at the shorter distances (2 and 4 km). However, at the longer distances (8 and 12 km), strength and endurance of the hamstrings and quadriceps muscles were signifcant predictors ($p<0.05$) of load bearing ability. Subjects whose mean % HRmax was above the group mean displayed higher correlations for hamstrings and quadriceps strength and endurance at the three longest march distances. These results suggest strength and endurance of the lower body to be important considerations in heavy load bearing performance.

The relationship of muscle fiber type and mass to maximal power production and the maintenance of power (endurance time to exhaustion) at 36, 55, and 73% of maximal power was investigated in 18 untrained but physically active male subjects. Power output was determined at constant velocity (60 RPM) on a high

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intensity cycle ergometer instrumented with force transducers and interfaced with a computer. Fat free mass was determined by hydrostatic weighing, fat free thigh volume by water displacement and skinfold measurement, and percentage and area of type II fibers from biopsies of the vastus lateralis.

Maximal power averaged 771 ± 149 W with a range of 327.1125 W. No significant correlations were found among percentage of type II fibers, relative area of type II fibers, or fat free thigh volume and maximal power or endurance times to exhaustion at any percentage of maximal power. Weak but significant relationships were found for fat free mass with both maximal power ($r=0.57$) and endurance time at 73% of maximal power ($r=0.47$). These results show maximal power to be more dependent on factors related to body size than muscle fiber characteristics. The low correlations for so many of the relationships, however, suggest that individuals employ different combinations of these factors in the physiological performance strategies utilized for the generation of high power outputs.

Research was carried out to examine the effects of three different run training programs on plasma responses of Beta-endorphin (B-EP) adrenocorticotropin (ACTH) and cortisol to maximal treadmill exercise. Subjects ($n=30$) were randomly assigned to one of three training groups; sprint intervals (SI), endurance (E) or combination (C). Training was monitored for 10 weeks and maximal treadmill exercise tests were administered pre- and post training. Blood samples were obtained before, immediately after, and 5 and 15 min following the maximal exercise tests. All groups significantly ($p<0.05$) increased maximal oxygen consumption values at 8 and 10 wk of the training period. Significant exercise-induced increases in plasma B-EP, ACTH, cortisol and blood lactate were observed for both pre- and post-training tests. The SI group demonstrated significant post-training increases in B-EP, ACTH, cortisol and peak 5 min post-exercise blood lactate concentrations in response to maximal exercise. No training-induced hormonal changes were observed for the E group. The C group exhibited significant post-training decreases in plasma B-EP. ACTH and blood lactate concentrations in response to maximal exercise, while resting and post-exercise plasma cortisol measures were significantly increased in the post-training test. These data suggest that different run training programs produce differential effects on plasma B-EP, ACTH and cortisol in response to maximal exercise, and these responses may be linked to anaerobic metabolic factors.

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Research was conducted to determine the effectiveness of psychophysical lifting training on maximal repetitive lifting capacity. Maximal repetitive lifting capacity was defined as the maximum box mass that could be lifted for a full hour to a height of 132 cm at a rate of 6 $lifts.min^{-1}$. Eight male subjects participated in five psychophysical lifting training sessions each week for four weeks. Each day subjects were presented one empty and one heavily loaded box and asked to adjust to the maximum load they felt capable of lifting for one hour. This load was lifted at a rate of 6 $lifts \bullet min^{-1}$ to a height of 132cm for two 15 minute sessions. After four weeks of training, subjects did not select a heavier training load, exhibit a decreased training heart rate, or report a decreased training RPE. The training program produced a significant increase in one hour maximal repetitive lifting capacity. The box mass selected for the maximal repetitive lifting capacity test increased significantly following training, with no concomitant change in VO^2, heart rate or RPE. It can be concluded that while psychophysical training is not a progressive resistive routine, a substantial increase in work output for a given energy expenditure can be expected in inexperienced lifters. These increases are attributed to neural factors and possible increases in the muscular endurance of specific muscle groups occurring with practice.

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EXERCISE PHYSIOLOGY DIVISION

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SIGNIFICANT TDY:

MAJ(P) Bruce H. Jones and staff of eight. Accession weight/fat standards research study, Sep-Dec 1988.

James A. Vogel, Ph.D., Chair NATO Research Study Group meeting on physical training. Brussels, Belgium, March 1988.

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SIGNIFICANT TDY:

James A Vogel and J. F. Patton. Load carriage research planning meeting. Army Physical Fitness School. Ft. Harrison, IN, 9-10 Feb 88.

James A. Vogel. Attend Secretary of the Army Quarterly Physical Fitness Meeting. Pentagon, Wash, DC, 14 Jan, 24 March, 21 July, 25 Oct 1988.

James A. Vogel. Attend DoD Human Factors Sub Technical Advisory Group Meeting on Sustained/Continuous Operations, Albuquerque, NM, 31 Oct - 4 Nov 1988.

James A. Vogel. Attend weekly meetings of the Massachusetts Governor's Panel on Police Academy Training, Worcester, Ma, Oct - Dec 1988.

SIGNIFICANT VISITORS:

Sigmund B. Stromme Ph.D. Professor, Norwegian School of Physical Education, Oslo, Norway, 6 June 1988

PROFESSIONAL APPOINTMENTS/ACTIVITIES:

James A. Vogel, Ph.D. Adjunct Professor, Department of Health Sciences, Boston University, Boston, MA.

Everett Harman, Ph.D. Adjunct Assistant Professor, Department of Health Sciences, Boston, MA.

James A. Vogel, Ph.D. Chairman, NATO Research Study Group - 17.

James A. Vogel, Ph.D., Everett Harman, Ph.D., John F. Patton, Ph.D.. Associate Editor, Journal for Applied Sport Science Research.

James A. Vogel, Ph.D. Chairman, American College of Sports Medicine Credentials Committee.

James A. Vogel. Member, Secretary of the Army Planning Committee for Physical Fitness.

James A. Vogel. Invited Member, Governor of Massachusetts Expert Panel to Review Police Training Programs, Boston, MA.

James A. Vogel. Member, DoD Human Factors Technical Advisory Group, Subgroup on Sustained/Continuous Operations.

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HEALTH AND PERFORMANCE DIVISION

SIGNIFICANT RESEARCH FINDINGS/DEVELOPMENTS:

Naval engineers proposed reducing the oxygen concentration in submarines below the normal ambient level of 21% to reduce the risk of and damage from fires. In a research study conducted with the Navy, the effects of reduced oxygen concentrations on human mental and physical performance, mood states, and symptoms of acute mountain sickness (AMS) were investigated. The results suggest that normobaric oxygen concentrations as low as 17% are not likely to produce adverse effects on cognition, mood states, or AMS symptomatology. However, oxygen concentrations as low as 13% are likely to adversely affect some performance tasks and moods, as well as induce AMS in about one-third of the exposed individuals.

The procedures for calculating the value of the alertness factor of the Environmental Symptoms Questionnaire (ESQ) were found to be invalid. Therefore, a new computational procedure for the alertness factor was developed and should be used whenever the ESQ is scored.

One of the first systematic and quantitative studies assessing the effects of altitude on mood compared moods measured at two different altitudes and two times of day using the Clyde Mood Scale. The moods of friendliness, clear thinking, dizziness, sleepiness, and unhappiness were adversely affected at 4300 m; only sleepiness changed at 1600 m. At 4300 m, the altered moods differed from baseline on the day of arrival (1 - 4 h), differed even more after one day (18 - 28 h), and returned to baseline by day 2 (42 - 52 h). Morning and evening values were similar at each altitude. Therefore, mood states were shown to have a distinct time course at altitude which is similar to acute mountain sickness.

Acutely stressful situations can disrupt behavior and deplete brain neurotransmitters. In animals, administration of tyrosine, a large neutral amino acid and dietary precursor of the catecholamines, reduced these behavioral and neurochemical deficits. In a prior study with humans, we found tyrosine reduced the adverse effects of cold and high altitude exposure in subjects who were most affected (average or greater than average adverse effects). In a second study, we investigated whether tyrosine (85 or 170 mg/kg) would protect humans from some of the adverse consequences of a longer exposure (7 h) to an environmental stressor (cold and high altitude). Symptoms, adverse moods, and performance impairments were greater with the longer exposure. Data analyses for the tyrosine treatment effect are in progress.

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Performances on three similar cognitive tasks with differing response requirements were compared under control and stressful environmental conditions. We developed an additional task with a dichotomous output response for administration with computer. The problem solving rate of this task was less than expected; however, its sensitivity and other psychometric properties were superior to the other tasks evaluated. These results illustrate that if performance tasks are developed thoughtfully for computer administration, their psychometric properties can be superior to those from their original media.

A study was conducted to evaluate the effects of sentry duty time on the soldier's speed of detection of visually presented targets, his ability to hit targets (rifle marksmanship), and his mood. Prior to the test day, each of eight subjects was given five days of training on the Weaponeer Rifle Marksmanship Simulator and was familiarized with the targets to be presented during testing. The test session lasted three hours, during which time the subject assumed a standing foxhole position and monitored the target scene of the Weaponeer Rifle Marksmanship Simulator. The Weaponeer M16A1 modified rifle lay next to the subject at chest height. When a pop-up target appeared, the subject pressed a telegraph key, lifted the rifle, aimed, and fired at the target. Speed of target detection was measured in terms of the time required by the subject to press the telegraph key in response to the presentation of the target. Marksmanship was measured in terms of number of targets hit. Speed of target detection and rifle marksmanship were averaged every 30 minutes. At the end of the test session, the subject completed the Profile of Mood States Questionnaire. The results showed that speed of target detection deteriorated with time on sentry duty; impairments were not evident within the first hour but were clearly evident by 1.5 hours. Marksmanship remained constant over time; soldiers were just as accurate in hitting the targets at the end of the 3 hours of sentry duty as they were at the beginning. Whereas the soldier's predominant mood during baseline practice sessions was one of vigor, during sentry duty the predominant mood was one of fatigue. The results of this study suggest that sentry duty performance may be optimized if it is limited to one hour or less.

Attitudes toward the cold, expectations concerning living and working in the cold, and subjective reports of psychological stress in daily life were measured on 59 soldiers prior to their participation in a rigorous cold weather military training program. During three days of training which were conducted entirely outdoors (including nighttime exercises and sleeping in the cold) at 0° to 32°F, soldiers were assessed twice daily on symptoms of

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physical illness and psychological mood. Statistical analyses showed that the more soldiers perceived their everyday lives as stressful and the more they expected to dislike cold weather training, the more likely it was that they would display symptoms of negative mood and poor physical well-being when actually undergoing cold weather military operations. This pattern of results supports the conclusion that the soldier's expectations and subsequent performance are intertwined, and that a soldier's expectations can be a powerful and independent predictor of subsequent moods and symptoms.

Contrast sensitivity thresholds were studied over 40 days during gradual ascent to a simulated terrestrial altitude of 25,000 feet in a decompression chamber. Only ambient pressure, and thus inspired oxygen pressure was varied, thereby eliminating many of the confounding effects of cold, dehydration, malnutrition and exhaustion, inevitably encountered on very high mountains. Contrast sensitivity thresholds measured by the Ginsburg Vistech test showed no overall impairment as altitude increased. These results are different from those of other previously reported vision studies involving shorter exposures, lower altitudes, and lower test luminances. However, the results can be explained on the basis of the higher stimulus luminances used in the contrast sensitivity testing. Compared to the stimulus luminance levels involved in previous research, the higher luminance stimuli used in this study would be less likely to be affected by hypoxia.

The logistical significance of chemical weapons in future warfare demands that nerve agent antidotes be available for troops exposed to chemical attack. Since future combat operations will most likely occur in tropical and desert areas, chemical attacks in such areas could lead to situations involving the use of nerve agent antidotes by troops during exposure to hot and hot-humid conditions. Virtually no data are available to estimate performance capabilities on psychologically based tasks under this combination of circumstances. This investigation assessed, both independently and in combination, the effects of heat exposure (95°F, 60%RH) and US Army standard dosages of nerve agent antidotes (2 mg atropine and 600 mg 2-PAM chloride) on the performance of a variety of tasks selected for their relevance to military operations. The tasks were selected from the USARIEM Performance Inventory (UPI) and assessed sensory functioning, perceptual-cognitive functioning, sensorimotor skill, subjective reactions, and direct military skills such as M-16 rifle marksmanship. The test design was repeated twice, with and without the subjects wearing chemical

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protective clothing. In Study 1, 15 soldier volunteers were first trained to asymptotic performance on the UPI task battery. Then, over a period of four test days, they completed a counterbalanced schedule of the drug/no drug and heat/no heat conditions while outfitted in the Battle Dress Uniform. On each test day, the tests from the UPI were administered once during each of three 2-hour test cycles. Compared to the placebo condition, a single dose of nerve agent antidote significantly impaired visual reaction time (5% slower for simple, and 11% slower for choice), gross body mobility (12% poorer), rifle marksmanship (3% less accurate), and verbal reasoning (6% slower). Compared to a 70°F control condition, 95°F ambient heat significantly impaired arm-hand steadiness (10% poorer), and rifle marksmanship (13% poorer). However, dexterity improved by 2 to 8 percent. Nerve agent antidote and ambient heat did not interact to further impair soldier performance. In Study 2, eight separate soldier volunteers were evaluated according to the same test procedures as in Study 1 with the exception that they were outfitted in the MOPP-IV chemical protective clothing ensemble. Subjective reports of mood and symptomatology related to the environment indicated that, with the drug, subjects dressed in MOPP-IV gear experienced more numerous bodily discomforts and negative moods than when dressed in the Battle Dress Uniform. The intensity of the symptoms were such that none of the subjects could complete the 95°F test sessions when dressed in MOPP-IV, and it was necessary to employ data substitution methods for analysis of the later cycles of Study 2 at 95°F. In Study 2, compared to the placebo condition, a single dose of nerve agent antidote significantly impaired reaction time (27% slower for simple, and 50% slower for choice), gross body mobility (12% less mobile), and rifle marksmanship (10% to 12% less accurate). In addition, two measures of cognitive activity were slowed (verbal reasoning by 14% and digit symbol substitution by 17%). Visual acuity, phoria (ocular muscle balance), and stereopsis (fine depth perception) were all significantly impaired by heat, drug, and the effects of continued exposure to the stress conditions. Visual contrast sensitivity was mainly affected by heat and continued exposure. The influence of heat alone was dramatic under MOPP-IV, in that all tests showed significant impairments under the 95°F conditions. This was attributed to the greatly increased heat load generated by wearing the impermeable MOPP-IV system. In Study 2, as in Study 1, nerve agent antidote and ambient heat did not interact to further impair soldier performance. An analysis of only the data for Cycle 1 of Study 2 (an analysis which required no data substitutions) also showed impairment of some tasks (visual acuity, reaction time, tremor, verbal reasoning), but these impairments were less extensive and were primarily due to drug effects. A separate analysis of overall endurance times of subjects in Study 2 showed that half of the subjects voluntarily withdrew, while the other half were removed by the medical

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monitor. Also, the group mean endurance time in the heat while wearing MOPP-IV was significantly shorter under drug antidote administration (149.25 minutes, SD = 39.93) than under placebo (183.62 minutes, SD = 29.74).

Contrast sensitivity has been identified as a significant index of visual function, and as an indicator of visual disorders. The Arden test of contrast sensitivity has been recognized as a simple and easily administered technique for measurement of this process. However, the customary administration of this test involves manual manipulation and considerable individual subjectivity. An instrument was designed and developed to minimize variability in the testing procedure due to differences in individual testing techniques, and to standardize testing conditions, ambient illumination, viewing distance and rates of presentation.

A chapter was written to be published in the "Handbook of Military Psychology" which summarizes, updates and comprehensively reviews the research literature on effects of hot and cold environments on psychological, perceptual, cognitive and subjective aspects of human behavior. A historical review of the development of this field of investigation is provided, along with its inter-relationship with relevant aspects of environmental physiology, biophysics, and problems of measurement. Applications of the available database to military operations and relevant human factors considerations are also discussed.

An animal research program was initiated in FY88 to focus on elucidating the relationship of brain neurotransmitter systems and cognitive information processing. Central neurotransmitter systems are manipulated by investigating, the separate and interactive effects of nutrient precursors of neurotransmitters (e.g. tyrosine, choline), pharmacologic agents (e.g. anticholinergics, anti-AChE) and environmental stress (e.g. heat, cold, hypoxia) on changes in brain neurochemistry and cognitive behavior.

The retention of a well-learned spatial task was assessed in rats after equal doses of atropine sulfate (30 mg/kg) were administered by intraperitoneal, subcutaneous or intravenous injection. Atropine sulfate disrupted first choice accuracy and escape latency measures of spatial retention. Intravenous and intraperitoneal atropine sulfate produced significant impairments in choice accuracy. However, only intravenous atropine sulfate produced a significant impairment in escape latency.

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Atropine sulfate administered subcutaneously never produced a significant impairment in spatial retention compared to the intravenous saline control. One would predict from the present findings that a centrally active drug might produce a highly variable effect on a specific behavior as a function of the parenteral route of administration.

Retention of a well-learned spatial task was assessed in rats 10 minutes prior to, and 10, 20, 30, 40 and 50 minutes after treatment with 3, 10 or 30 mg/kg, iv, atropine sulfate or the equivalent volume of saline, iv. There was a variable dose effect for escape latency and choice accuracy measures of spatial retention. A relatively large dose of atropine sulfate (30 mg/kg, iv) significantly impaired choice accuracy and escape latency compared with the control group. Moreover, impairment in choice accuracy was observed with smaller doses of atropine sulfate (3, 10 mg/kg, iv) than have previously been shown to disrupt spatial retention.

Twelve rats were trained to learn the location of a spatially fixed platform hidden in a Morris water maze. Asymptotic performance was achieved over six training days (10 trials/day). Then retention of the spatial task was assessed 30 minutes after treatment with 5, 25, 50, 75 or 100 mg/kg, ip, atropine sulfate or the equivalent volume of saline. There was a significant, dose-dependent, drug effect on escape latency, swim distance, swim speed and swim path measures of spatial performance. There was no significant drug effect on heading error; atropinized animals swam directly toward the escape platform over the first 12 cm of their swim path. However, treatment with atropine sulfate significantly disrupted the usual, direct swim path used to reach the hidden escape platform. Atropinized animals frequently swam within a 30 cm wide alley directly toward the platform but used one or more 360° loops to locate the platform. We suggest that cholinergic blockade may significantly disrupt the processing of distal visual cues which rats use in place navigation tasks.

Fifteen rats were trained to learn the location of a spatially fixed platform hidden in a Morris water maze (14-16° C). Asymptotic performance was achieved over six training days (10 trials/day). Then retention of the task was assessed immediately after lowering core body temperature (T_C) to 28° or 30° C or stabilizing at 37° C (the normothermic control). The hypothermia treatment order was counterbalanced according to a Latin-square design. Hypothermia significantly impaired spatial performance. Hypothermic animals were rewarmed in a 40° C water bath to 37° C T_C and spatial

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SIGNIFICANT RESEARCH FINDINGS/DEVELOPMENTS:

performance tested again. Artificial rewarming reversed the hypothermia-induced amnesia. These results demonstrate that hypothermia-induced amnesia can be obtained on an overtrained spatial mapping strategy and artificial rewarming initiates complete recovery of spatial performance.

Fifteen rats were trained to learn the location of a spatially fixed platform hidden in a Morris water maze (40 $\pm$ 2° C). Then retention of the spatial task was assessed immediately after raising core body temperature (T_c) to 42° or 40° C or stabilizing at 37° C (the normothermic control). The hyperthermic treatment order was counterbalanced according to a Latin-square design. Hyperthermia at 42° C T_c significantly impaired the retention of spatial performance. Hyperthermic animals were cooled to normothermia (T_c = 37° C) and spatial performance tested again. Cooling resulted in a complete recovery of spatial performance. These results demonstrate that hyperthermia-induced amnesia can be obtained on an overtrained spatial mapping strategy and cooling to normothermia initiates recovery of spatial performance.

PUBLICATIONS:

Johnson, R.F., L.G. Branch, and D.J. McMenemy. Attitudes towards the cold: Effects on psychological mood and subjective reports of illness during cold weather training. USARIEM Technical Report No. T11-88, 1988.

Johnson, R.F. and J.L. Kobrick. Ambient heat and nerve agent antidotes: Effects on soldier performance with the USARIEM Performance Inventory. In Proceedings of the Human Factors Society 31st Annual Meeting (pp. 563-567). Santa Monica, CA: Human Factors Society, 1988.

Kobrick, J.L., R.F. Johnson, and D.J. McMenemy. Nerve agent antidotes and heat exposure: Summary of effects on task performance of soldiers wearing BDU and MOPP-IV clothing systems. USARIEM Technical Report No. T1-89, 1988.

Kobrick, J.L., E. Crohn, B. Shukitt, C.S. Houston, J.R. Sutton and A. Cymerman. Operation Everest II: Lack of an effect of extreme altitude on visual contrast sensitivity. Aviat. Space Environ. Med. 59:160-164, 1988.

Kobrick, J.L., H.I. Zeltzer and S.P. Mullen. A system for controlled presentation of the Arden contrast sensitivity test. Aviat. Space Environ. Med. 59:667-669, 1988.

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PUBLICATIONS:

Rauch, T.M., E. Gallego and D.I. Welch. retention of a spatial task after intraperitoneal, subcutaneous or intravenous injections of equal doses of atropine. Life Sci, 43:1913-1920, 1988.

Shukitt, B.L. and L.E. Banderet. Mood states at 1600 and 4300 m terrestrial altitude. Aviat. Space Environ. Med. 59:530-532, 1988.

Shukitt, B.L., R.L. Burse, L.E. Banderet, D.R. Knight and A. Cymerman. Cognitive performance, mood states, and altitude symptomatology in 13-21% oxygen environments. USARIEM Technical Report No. T18-88, 1988.

Tharion, W.J., S.R. Strowman and T.M. Rauch. Profiles and changes in moods of ultramarathons. J. Sport Psych. 10:229-235, 1988.

PRESENTATIONS:

Banderet, L.E., B.L. Shukitt, M.A. Walthers, R.S. Kennedy, A.C. Bittner Jr., and G.G. Kay. Psychometric properties of three addition tasks with different response requirements. 30th Annual Conference of the Mil. Test. Assoc. Arlington, VA, November, 1988.

Johnson, R.F., L.G. Branch, and D.J. McMenemy. Attitudes and reports of illness during cold weather military training. Paper presented at the annual meeting of the American Psychological Association, Atlanta, GA: August, 1988.

Shukitt, B.L. and L.E. Banderet. Cognitive performance and mood states in 13-21% oxygen environments. 30th Annual Conference of the Mil. Test. Assoc. Arlington, VA, November, 1988.

Tharion, W.J. and D.J. McMenemy. Time series of moods associated with running on ultramarathon. New England Chapter of the American College of Sports Medicine Annual Meeting. Worcester, MA, November 1988.

KEY BRIEFINGS:

Johnson, R.F. Subjective reaction to the environment: Assessing soldiers' moods and reports of symptoms. Lecture presented at the course Current Concepts in Environmental Medicine, US Army Research Institute of Environmental Medicine, Natick, MA: May 1988.

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SIGNIFICANT TDY:

Terry M. Rauch, MAJ, Ph.D. Participated in a brain microdialysis course at the Carnegie Medicin Institute and the Karolinska Institute, Stockholm, Sweden, 11-18 November, 1988.

SIGNIFICANT VISITORS:

Mr. Tom Keel, Engineer, McDonnell-Douglas, St. Louis, Missouri
Topic: modelling of aircrew performance in chemical protective clothing

PROFESSIONAL APPOINTMENTS/ACTIVITIES:

Louis E. Banderet, Ph.D. Reviewer of Psychology Textbooks for McGraw Hill and Scott Foresman Publishers Inc.

Richard F. Johnson, Ph.D. Lecturer in Psychology, Northeastern University, Boston, MA

Richard F. Johnson, Ph.D. Editorial Consultant, Exercise and Sport Sciences Reviews

Richard F. Johnson, Ph.D. Editorial Consultant, Psychosomatic Medicine

Richard F. Johnson, Ph.D. Corresponding Associate Commentator, The Behavioral and Brain Sciences

Richard F. Johnson, Ph.D. Member, Technical Group Advisory Committee, Human Factors Society

Richard F. Johnson, Ph.D. Member, Quality Assurance Committee, US Army Research Institute of Environmental Medicine, Natick, MA

HEAT RESEARCH DIVISION

SIGNIFICANT RESEARCH FINDINGS/DEVELOPMENTS

The effects of an intense, intermittent heat acclimation (HA) regimen (8 days, 63-72 % VO_2 peak, 100 min-day^{-1}, treadmill, 41.2°C) on stress and fluid-balance hormones and plasma electrolytes were examined in 13 unacclimated males. Venous blood samples (pre- and post-exercise; days 1,4,8 of HA) were analyzed for plasma renin activity (PRA), aldosterone (ALD), plasma cortisol (PC), plasma volume shifts (PV%), and plasma sodium (Na^+), and potassium (K^+). Subjects exhibited the physiological adaptations (day 1 vs 8) typical of HA ($p<.05$): decreased heart rate (HR), rectal temperature (Tre), mean skin temperature (Tsk), and improved defense of PV. While Na^+ demonstrated no within day change, K^+, PC, PRA, and ALD increased significantly ($p<.01$ to $p<.05$). Between days 1 and 8 of HA, PRA, ALD, Na^+, and K^+ responses did not change, but significant within-day increases of PC were attenuated by day 8. It was concluded that the acquisition of HA (day 1 vs 8) via intense, intermittent exercise resulted in reduced strain (e.g. PC, HR, Tre, Tsk, PV%), but no change in fluid-balance hormones (PRA,ALD).

Mass-to-surface area ration (M/SA) was calculated from the body weight and skin surface area of 1513 male and female U.S. Army personnel. It has been suggested that M/SA plays a role in thermoregulation, particularly in hot-humid environments, since both body weight and surface area affect the rate of body heat storage. The purpose of this investigation was to provide a data base to be used when interpreting M/SA data in future studies. The effects of gender, ethnic group, and age on the distribution of M/SA were examined, in addition to the relationship between M/SA and other physical characteristics. Important findings may be summarized as follows: (1) M/SA increased significantly in females after age 24, and after age 29 in males ($p<.025$). Therefore, M/SA values should be compared with data in the appropriate age group. The increase in M/SA with age may be explained by an increase in percent body fat (%BF). %BF increased significantly in both males and females after age 24 ($p<.025$). (2) M/SA was statistically similar between ethnic groups in both males and females. However, black males had a lower %BF and a larger fat-free mass than males in other ethnic groups ($p<.001$). (3) For the first time, four equations are presented which allow an accurate calculation of M/SA ($r^2 = .99$) using only height and weight. The results of this investigation will be useful in analyzing data in future studies designed to determine if M/SA is in fact an index of heat tolerance.

The change in core temperature of three healthy, normothermic men was studied during immersion in 25, 28, or 30°C water, with and without pretreatment with nicotinic acid. The subjects wore shorts and reclined on lounge chairs in water covering all skin below the neck. They ingested 1000 mg of nicotinic acid and

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entered the water after a clearly visible flush had developed (range, 15 to 37 min). Core temperature was measured by either esophageal thermistor (subjects 1 [Bd 3) or rectal probe (subject 2). Nicotinic acid pretreatments resulted in greater body cooling than control trials. However, the changes in core temperature were less than those that can be achieved with evaporative cooling techniques. Despite the fact that subjects 1 (age 47) and 2 (age 33) were considerably more obese than subject 3 (age 36), subjects 1 and 2 exhibited more intense flushing and greater core temperature changes than subject 3. Body cooling was greater in 30°C water than in 28 or 25°C water, confirming that shivering and vasoconstriction counteract net heat loss. The striking feature of the nicotinic acid trials was the magnitude of body cooling (approx. 0.7 to 1.0°C) achieved in relatively temperate water (30°C). The results of these preliminary trials suggest that a detailed investigation of the use of nicotinic acid as a pretreatment (oral or intravenous) for cooling heatstroke victims is warranted.

Heat stress causes a displacement of blood flow to dilated peripheral veins in man and many animals for heat dissipation. Exercise in the heat effects competition for cardiac output between working muscles and peripheral sites of heat loss. The role of sympathetic activity at a time of increased demand for both heat loss and muscle blood flow during exercise/heat stress was studied in a validated rat model. The data indicated that during exercise there occurred characteristic increases in thermoregulatory (Tc 37.1 vs 40°C, Tp 26.8 vs. 32.9°C), cardiovascular (BPc 119/101 vs 135/120 mm Hg, BPp 115/106 vs 135/118 mm Hg) and circulating neuroendocrine variables (Norepi+150%, Epi+25%). However, at exhaustion (end of run, X=68 min) a divergence in peripheral versus central body temperature and blood pressure was noted while circulating catecholamines remained elevated. We concluded that since catecholamines remained elevated while peripheral temperature and blood pressure declined, a centrally controlled peripheral vasoconstriction is operative to maintain cardiovascular stability. We hypothesize that the protection of central BP and cardiac output supersedes the demands of peripheral temperature regulation.

Rats (adult male, n=12/group) were pretreated with saline (control, C), low dosage scopolamine (18.1 ug/kg, LS), high dosage scopolamine (35.6 ug/kg, HS), low dosage aprophen (3.6 mg/kg, LA) or high dosage aprophen (6.3 mg/kg, HA) before exercise (11 m/min, 0° angle, 26°C). In the HS group endurance was reduced to 57 min (88 min, C) with an accompanying increase in heating rate (.032°C/min, C vs .053°C/min, HS). Endurance was also slightly decremented in HA (73.1 min) and heating rate was marginally increased (.038°C/min). During the treadmill interval C rats lost 18.2 g as salivary water, while HS and HA

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11.5 and 12 g respectively. Following completion of treadmill exercise, lactate levels were significantly increased only in the HS group indicating that HS may have elicited a metabolic effect not produced by the other treatments. The nicotinic and muscarinic effects of anticholinergics can be separated by assessing effects on performance and thermoregulation in our rat model of human heat/exercise injury.

A new theory of heat illness pathophysiology called the energy depletion model first appeared in a review article (Hubbard, R.W., C.B. Matthew, M.J. Durkot and R.P. Francesconi. Novel approaches to the pathophysiology of heatstroke: The energy depletion model. Ann. Emerg. Med. 16:, 1066-1075, 1987). The focal point of this theory is the impact of heat, cold and dehydration on the permeability of the cell membrane to sodium and potassium ions resulting in the stimulation of the sodium pump located in the cell membrane. This pump responds to changes in membrane permeability to sodium by adjusting the rate it pumps sodium out of the cell and potassium in as well. This process requires the input of cellular energy in the form of ATP. Dr. Hubbard has brought substantial published evidence to bear on this concept in two new book chapters (Hubbard, R.W. and L.E. Armstrong. The heat illnesses: biochemical, ultrastructural, and fluid-electrolyte considerations. In: Human Performance Physiology and Environmental Medicine at Terrestrial Extremes. K. B. Pandolf, M.N. Sawka and R.R. Gonzalez, eds., Indianapolis: Benchmark Press, pp. 305-359, 1988; and Yarbrough, B.E. and R.W. Hubbard. Heat-related illnesses. In: Management of Wilderness and Environmental Emergencies, 2nd Ed. C.B. Mosby Co., St. Louis, MO (In Press). This additional material argues strongly that this process is highly dependent upon ATP derived via glycolytic mechanisms. This model describes how ion pumping rate becomes a measure of physiological strain at the cellular level. A crisis point for the cell is reached when the metabolic demand for ion pumping cannot be met by the available energy supplies. This energy depletion phase can lead to cell swelling, infarction and death. Interestingly, this model was easily adapted to explain various research findings in the area of thirst research and suggested that the so-called osmoreceptor implicated as the receptor for thirst could be an energy receptor geared to sodium permeability (Hubbard, R.W., P.C. Szlyk, and L.E. Armstrong. Influence of Thirst and Fluid Palatability on Fluid Ingestion During Exercise. In: Perspectives in Exercise Science and Sports Medicine: Volume 3. Fluid Homeostasis During Exercise. In press 1989 and Hubbard, R.W., P.C. Szlyk and L.E. Armstrong. Solute model or cellular energy model?: Practical and theoretical aspects of thirst during exercise. Presented to the Committee on Military Nutrition, National Academy of Sciences and National Research Council, Washington D.C., 16 Feb 1989).

HEAT RESEARCH DIVISION

SIGNIFICANT RESEARCH FINDINGS/DEVELOPMENTS

Preliminary tests of satellite remote sensing methods being developed under SBIR Contract No. DAMD17-86-C-6004 (Gulf Weather Corp.), were conducted during reserve training operations at Fort Hood, Texas, in June 1988. Using data obtained from polar orbiting weather satellites, the surface level Wet Bulb Globe Temperature (WBGT) heat stress index was estimated and compared with simultaneous measurements made on the ground. The heat stress "image" obtained using the satellite method provides a color map overlay for an area 250 km X 250 km, and consists of more than 50,000 pixel (1.1 X 1.1 km) estimates of WBGT. For the 11 satellite passes obtained for Fort Hood, the average difference between the satellite-derived WBGT and the surface WBGT measurement was -1.0°C (too low) and the variation was ± 2.1°C. Work is in progress to improve the accuracy of the satellite methods. The development of this technology and its integration with the Army's satellite data collection and processing facilities may have significant value for the prevention of heat injury in both training and operational settings.

We have reported that the administration of physostigmine (PH) to rats (500g) exercising on a treadmill (26°C,50% rh, 11 m/min, 6° incline) results in a decrement in both endurance (decreased running time to exhaustion) and increased heating rate (rate of rise of core temperature). In the present work, a commercially available kit for cholinesterase (ChE) activity was modified to quantitate a PH-induced dose-response whole blood % ChE inhibition. The following linear regression was derived from the data: $Y = 85.9 + 13.5 X$ (Y = % ChE inhibition, X = natural log of the dose of PH in mg/kg of freebase PH). We then administered 50, 100, and 200 ug/kg of PH salicylate (40, 50, and 60% ChE inhibition) to rats prior to running on a treadmill. The saline control group (n=12/group) ran for 67±6 min (mean ± SE) and had a heating rate of 0.051± 0.007°C/min. The run times and heating rates for the PH groups, expressed as % of saline control values, were as follows: 50 ug/kg- 80, 116%; 100 ug/kg- 64,180%; and 200 ug/kg- 48,214%. Therefore, we have now characterized the dose-response performance decrements associated with 40, 50 and 60% ChE inhibition, and we can now use this model to examine the efficacy of adjuncts to attenuate PH-induced performance decrements.

Heat strain and plasma hormones were measured in 15 unacclimated men on two non-consecutive days during 6h of intermittent exercise (50min/h, 4km/h) in warm conditions (30°C d.b./18°C w.b.) while drinking water ad lib. On one day clothing was either Army fatigues (BDU) or impermeable gear over the fatigues (IC). During the second trial, a hooded mask was worn with the IC gear (ICM). Compared to the calculated change in heat storage (S) in BDU (7±3 kcal/m^2), IC increased S (16±3 kcal/m^2) and ICM exacerbated this increment (33± kcal/m^2).

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Final exercise Tre was not different betwen BDU and IC (37.6$\pm$.1°C) but was increased in ICM (38.1$\pm$.1°C). Surprisingly, final 3 point Tsk (forearm, calf, chest) rose significantly when the hooded mask was added (35.7$\pm$2°C) compared to IC (34.9$\pm$.04°C) and BDU (33.9$\pm$.2°C). Although plasma volume (PV) increased during the BDU trial (1.1$\pm$1.5%), donning impermeable gear and mask increased sweat rate and reduced water intake causing progressive PV deficits in IC (-2.0$\pm$1.3%), and ICM (-8.5$\pm$1.6%). Exercise increased plasma levels of cortisol (Δ =4.4ug/dl), renin activity (PRA, Δ = 8.3 ng/ml/h) and aldosterone (ALD, Δ = 26.9 ng/dl) only in ICM. While cortisol levels were significantly correlated with ΔTre and ΔS, PRA and ALD were more closely associated with %Δ PV and HR. Thus, heat stress was increased when IC was worn, and the masked configuration elicited further elevations in heat storage and hypohydration.

Urinary specific gravity (USG) and electrolytes and fluid intake were monitored twice daily to assess hydration status in 61 male and female soldiers (34$\pm$1 yr) (X$\pm$SE) during hot weather field training (max Tamb=31-38°C) for 8 days. Subjects consumed one of 4 beverages (25$\pm$1°C) ad lib: a flavored 2.5% glucose electrolyte drink with (GE1) or without (GE2) Mg^{+2}, K^+, and PO_4, or water (W), or flavored water (placebo, FW). USG displayed a diurnal periodicity, with morning (0700h) values higher than late afternoon (1600h). W had the highest incidence of USG$\geq$1.030 (22%) whereas only 8% of the samples from FW had USG$\geq$1.030. Increased heat stress elevated USG in all groups despite enhanced fluid intakes. On the hottest day, incidence of USG$\geq$1.030 peaked in groups GE1 (33%) and W (34%); in FW and GE2 significantly lower incidences (8% and 0%) of USG$\geq$1.030 were observed. Individuals having USG$\geq$1.030 consumed about 22% less fluid than those with USG$\leq$1.030. Likewise, urinary creatinine concentration obtained the morning after the hottest day were significantly greater for GE1 and W compared to FW and GE2. UNa^+ and UK^+ mirrored electrolyte ingestion. GE2 and FW were rated more favorably than GE1 and W, and this preference was reflected in the greater intakes of GE2 and FW. GE2 and FW were effective in reducing the incidence of hypohydration by enhancing fluid intake during field training in hot climates.

PUBLICATIONS

Armstrong, L.E., R.W. Hubbard, P.C. Szlyk, I.V. Sils, and W.J. Kraemer. Heat intolerance, heat exhaustion monitored: A case report. Aviat. Space Environ. Med. 59:262-266, 1988.

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PUBLICATIONS

Armstrong, L.E. and R.W. Hubbard, Y. Epstein and R. Weien. Nonconventional remission of miliaria rubra during heat acclimation: Case study. Milit. Med. 153:402-404, 1988.

Armstrong, L.E. and K.B. Pandolf. Physical Training, Cardiorespiratory Physical Fitness and Exercise-Heat Tolerance. In: Human Performance Physiology and Environmental Medicine at Terrestrial Extremes. K.B. Pandolf, M.N. Sawka, R.R. Gonzales (Eds). Indianapolis:Benchmark Press, 1988, pp. 305-359.

DeLuca, J.P., L.E. Armstrong, E.L. Christensen and R.W. Hubbard, J.A. Vogel and D.D. Schnakenberg. Mass-to-Surface area ratio in military personnel. USARIEM Technical Report No. T21-88, 1988.

Francesconi, R.P., R. Hubbard, C. Matthew, M. Durkot, M. Bosselaers, and N. Leva. Exercise in the heat: Effects of dinitrophenol administration. J. Therm. Biol. 13:189-195, 1988.

Francesconi, R.P., M.N. Sawka, R.C. Dennis, R.R. Gonzalez, A.J. Young, and C.R. Valeri. Autologous red blood cell reinfusion: Effects on stress and fluid regulatory hormones during exercise in the heat. Aviat. Space Environ. Med. 59:133-137, 1988.

Francesconi, R.P. Endocrinological Responses to Exercise in Stressful Environments. In: Exercise and Sports Sciences Reviews. K.B. Pandolf (Ed.) Macmillan Publishing Co., New York, 1988, pp 255-284.

Hubbard, R.W. and L.E. Armstrong. The Heat Illnesses: Biochemical, Ultrastructural and Fluid-Electrolyte Considerations. In: Human Performance Physiology and Environmental Medicine at Terrestrial Extremes. K.B. Pandolf, M.N. Sawka, R.R. Gonzalez (Eds). Indianapolis:Benchmark Press, 1988, pp. 199-226.

Hubbard, R.W., L.E. Armstrong and A.J. Young. Rapid hypothermia subsequent to oral nicotinic acid ingestion and immersion in warm (30°C) water. Correspondence. Am. J. Emerg. Med. 6:317-318, 1988.

Matthew, C.B., G.J. Thomas, R.W. Hubbard, and R.P. Francesconi. Intramuscular and intravenous atropine: Comparison of effects in the heat-stressed rat. Aviat. Space Environ. Med. 59:367-370, 1988.

Matthew, C.B., R.W. Hubbard, R.P. Francesconi, and G.J. Thomas. Carbamates, atropine and diazepam: Effects on performance in the running rat. Life Sci. 42:1925-1931, 1988.

HEAT RESEARCH DIVISION

PUBLICATIONS

Matthew, C.B., C.L. Chapin, R.P. Francesconi, and R.W. Hubbard. Spectrophotometric measurement of circulating cholinesterase. USARIEM Technical Report No. T/14, 1988.

Szlyk, P.C., K.C. Evans and I.V. Sils. Validation of a modified one-step rebreathing technique for measuring exercise cardiac output. Aviat. Space and Environ. Med. 59:1193-1197, 1988.

Szlyk, P.C., K.C. Evans and I.V. Sils. Validation of a modified one-step rebreathing technique for non-invasive measurement of submaximal cardiac output. USARIEM Technical Report No. T8, 1988.

ABSTRACTS

Armstrong, L.E., R.P. Francesconi, W.J. Kraemer, J.P. DeLuca, and R.W. Hubbard. Plasma cortisol, renin and aldosterone responses during an intense heat acclimation regimen. Med. Sci. Sports Exercise. 20:S70, 1988.

Durkot, M.J., O. Martinez, V. Pease, R. Francesconi, and R. Hubbard. The relationship of plasma catecholamines to peripheral blood flow and thermoregulation. FASEB J. 2:A747, 1988.

Matthew, C.B., R.W. Hubbard and R.P. Francesconi. Atropine, dizaepam and physostigmine: Thermoregulatory effects in the heat-stressed rat. FASEB J. 2:A747, 1988.

Szlyk, P.C., I.V. Sils, R.P. Francesconi, and R.W. Hubbard. Effects of impermeable protective gear on voluntary dehydration. FASEB J. 2:A522, 1988.

PRESENTATIONS

Armstrong, L.E. Running safely in the heat. Seminar, Health Fair, Worcester, MA, April 1988.

Armstrong, L.E. Emergency treatment of heat injury. Emerson Hospital, Concord, MA, May 1988.

Armstrong, L.E. Principles for acclimatizing athletes to heat, cold, altitude and air pollution: What can and cannot be done. National Strength & Conditioning Association, Orlando, FL, June 1988.

HEAT RESEARCH DIVISION

PRESENTATIONS

Armstrong, L.E. Effects of cold and hot environments on athletic performance. U.S. Olympic Training Center, Colorado Springs, CO, Oct 1988 and Dec 1988.

Armstrong, L.E. Influence of air pollution, altitude, cold and heat on cardiac rehabilitation patients. Newton-Wellesley Hospital, Newton, MA, Nov 1988.

Francesconi, R.P., M.W. Sawka, R.W. Hubbard, and K.B. Pandolf. Hormonal regulation of fluids and electrolytes: Effects of heat exposure and exercise in the heat. Federation of American Societies for Experimental Biology. Las Vegas, NV, April 1988.

Matthew, W.T., G.J. Thomas, M. Rose, R.W. Hubbard, R. Whang, F.J. Schatzle, J.D. Baldwin, S.A. Hsu, O.K. Huh, and F.L. Quirk. Satellite remote sensing of heat stress during reserve training at Fort Hood. Ninth Annual EOSAEL/TWI Conference, Las Cruces, NM, December 1988.

Matthew, C.B. The heat-stresed and exercising rat: Models for anticholinergic and anticholinesterase drug testing. Southern Illinois University School of Medicine. Springfield, IL, May 1988.

KEY BRIEFINGS

Lawrence E. Armstrong, Ph.D. Heat injury prevention in arid and tropical environments. 101st Airborne Division, Fort Campbell, KY, 1988.

Lawrence E. Armstrong, Ph.D. Field recognition of heat injuries. 44th Evac Hospital, Fort Hood, TX, 1988.

Lawrence E. Armstrong, Ph.D. Time course and extent of recovery in prior heatstroke patients. Medical Officer's Short Course, Baltimore, MD, 1988.

Lawrence E. Armstrong, Ph.D. Prevention of heat injury in field engineering units. Fifth United States Army Reserves, Dallas, TX, 1988.

Ralph P. Francesconi, Ph.D. Military operations in hot environments: Prevention of heat injury. Iowa Army National Guard Safety Conference, Des Moines, Iowa, 1988.

Ralph P. Francesconi, Ph.D. Military operations in hot environments: Prevention of heat injury. Fifth Army Command (Res), Commander and Safety Officers, Columbia, MO, 1988.

HEAT RESEARCH DIVISION

KEY BRIEFINGS

Ralph P. Francesconi, Ph.D. Temperature regulation in hot environments. Brockton VA Hospital, Grand Rounds, Brockton, MA, 1988.

Ralph P. Francesconi, Ph.D. Heat Research Division field research, CG, Health Services Command, Ft. Hood, TX, 1988.

Roger W. Hubbard, Ph.D. DOD Multi-Service Steering Group for the evaluation of military field water quality, Fort Detrick, MD, 1988.

Roger W. Hubbard, Ph.D. Medical Officer's Short Course, Current issues in heat injury prevention with special emphasis on the interaction of ROWPU and ration salt contents. Baltimore, MD, 1988.

Roger W. Hubbard, Ph.D. US Army Medical-Chemical Defense General Officer Review (MG Watson, MG Russell, BG Lanoue, BG Hidalgo) of hydration methods to maintain performance of soldiers in MOPP IV including: Water demand issues, FIST-FLEX personal water supply system, canteen-refilling-resupply issues, Fort McClellan, AL, 1988.

William T. Matthew. Heat stress assessment and drinking water requirements; AMEDD Working Group, Water Resources Management Action Group (WRMAG), Ft. Belvoir, VA, May 1988.

William T. Matthew. Weather data resources to support heat injury prevention; USARIEM Course, Natick, MA, May 1988.

William T. Matthew. Environmental heat stress measurement, 44th Medical Evacuation Hospital, Fort Hood, TX, June 1988.

Patricia C.-Szlyk, Ph.D. Increasing fluid intake and preventing dehydration in troops working in desert climates. 44th Evacuation Hospital, OK, June, 1988.

SIGNIFICANT TDY

Ralph P. Francesconi, Ph.D., Patricia C. Szlyk, Ph.D., Lawrence E. Armstrong, Ph.D., and William T. Matthew. To participate in a field study on acceptability and effectiveness of nutrient solutions in preventing heat casualties at Operation Dusty Bull, Ft. Hood, TX, 7-15 June 1988.

HEAT RESEARCH DIVISION

SIGNIFICANT VISITORS

Atty. Diane Juliar, Assistant District Attorney, District Attorney's Office, Cambridge, MA.

PROFESSIONAL APPOINTMENTS/ACTIVITIES

Lawrence E. Armstrong, Ph.D. Adjunct Professor, University of Connecticut at Storrs.

Lawrence E. Armstrong, Ph.D. Executive Board, New England Chapter of American College of Sports Medicine.

Lawrence E. Armstrong, Ph.D. National Fluid Replacement During Exercise Position Statement Committee, American College Sports Medicine.

Lawrence E. Armstrong, Ph.D. Developmental Task Force, National Strength and Conditioning Association.

Michael J. Durkot, M.S., Ph.D. Executive Committee Sigma Xi, The Scientific Research Society Natick Chapter.

Ralph P. Francesconi, Ph.D. Chairman, Laboratory Animal Care and Use Committee, USARIEM, 1988.

Ralph P. Francesconi, Ph.D. Member, Quality Assurance Committee, USARIEM, 1988.

Ralph P. Francesconi, Ph.D. Reviewer, Aviation Space and Environmental Medicine, 1988.

Ralph P. Francesconi, Ph.D. Reviewer, Journal of Applied Physiology, 1988.

Ralph P. Francesconi, Ph.D. Advisor, National Academy of Sciences/National Research Council Associateship Program, 1988.

Ralph P. Francesconi, Ph.D. Contracting Officer's Representative, USAMRDC, 1988.

Ralph P. Francesconi, Ph.D. Reviewer, Army Research Office, 1988.

Ralph P. Francesconi, Ph.D. Reviewer, American Institute of Biological Sciences, 1988.

HEAT RESEARCH DIVISION

PROFESSIONAL APPOINTMENTS/ACTIVITIES

Ralph P. Francesconi, Ph.D. Reviewer, American College of Sports Medicine, 1988.

Roger W. Hubbard, Ph.D. Adjunct Professor of Pathology, Boston University School of Medicine, Boston, MA.

Roger W. Hubbard, Ph.D. Member, DOD-Water Resources Management Action Group (WRMAG), 1980 to present.

Roger W. Hubbard, Ph.D. Member, DOD-Steering Committee on Field Water Quality.

Roger W. Hubbard, Ph.D. Reviewer, Aviation Space and Environmental Medicine, 1988.

Roger W. Hubbard, Ph.D. Reviewer, Journal of Applied Physiology, 1988.

Roger W. Hubbard, Ph.D. Reviewer, Journal of Wilderness Medicine, 1988.

Patricia C. Szlyk, Ph.D. Reviewer, Aviation Space and Environmental Medicine.

Patricia C. Szlyk, Ph.D. Science Fair Judge at 33rd Annual Worcester Regional Science and Engineering Fair.

Patricia C. Szlyk, Ph.D. Science Fair Judge (Special Awards Judge) for the International Science and Engineering Fair.

Patricia C. Szlyk, Ph.D. Elected Admissions Committee, Sigma Xi Honor Society, Natick Chapter.

MILITARY ERGONOMICS DIVISION

SIGNIFICANT RESEARCH FINDINGS/DEVELOPMENTS:

We wanted to determine whether heat-acclimated subjects, as well as hypohydrated subjects, would have a thermoregulatory advantage from acute polycythemia during exercise in the heat. Five heat-acclimated males attempted four heat stress tests (HSTs): two pre- and two post-infusion. Autologous erythrocyte infusion was accomplished with 500 ml of a NaCl-glucose-phosphate solution containing ~60% hematocrit. One HST, both pre- and post-infusion, was done while subjects were euhydrated, and one HST was done while subjects were hypohydrated (-5% of body weight). The findings concerning acute polycythemia in heat-acclimated subjects are summarized: 1) polycythemia increased sweating rate and reduced core temperature during exercise-heat stress for both euhydrated and hypohydrated subjects; 2) the erythrocyte infusion caused an increased plasma volume and increased blood volume; 3) the increased plasma volume was associated with an increased total circulating protein mass; 4) the increased total circulating protein mass tended to better maintain plasma volume when hypohydrated; and 5) heat acclimation may increased extravascular protein mass. Therefore, it is concluded that erythrocyte infusion provides a thermoregulatory advantage during exercise in the heat for heat-acclimated subjects when both euhydrated and hypohydrated.

The energy cost of prolonged walking while carrying a backpack load was examined. Six trained subjects were tested while walking for 120 min on a treadmill at a speed of 1.25 $m \cdot s^{-1}$ and 5% elevation with a well-fitted backpack load of 25 and 40 kg alternately. Carrying 40 kg elicited a significantly higher energy cost than 25 kg. Furthermore, whereas carrying 25 kg resulted in a constant energy cost, carrying 40 kg yielded a highly significant increase in energy cost over time. The study implies that increase in load causes physical fatigue, once work intensity is higher than 50% of maximal work capacity. This is probably due to altered locomotion biomechanics, which in turn lead to the increase in energy cost.

In our study comparing two versions of the (interim) self-contained toxicologic environmental protective outfit (STEPO) with the currently field toxicological agent protective suit (TAP), soldiers wore these suits on separate days, while walking on a treadmill in a hot (38°C, 30% rh) and a temperature (18°c, 30% rh) environment. In the heat, the STEPO tether system (cooled with ambient air), allowed the soldiers to walk significantly longer (65 min) than the other two suits (STEPO rebreather 55 min, TAP 51 min). This was likely due to the much higher rate of evaporated sweat in that system.

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The rectal temperatures were lower in the tether system, but heart rates were not. In the cool condition, there were no significant differences in exercise times or rectal temperatures, although only in the TAP suit were all the soldiers able to complete two hours. A drawback to the STEPO systems was their cumbersome bulk and weight (20 and 30 kg), a decided factor in at least two minor back injuries which resulted in the end of testing for one of these subjects.

It is estimated that 3-4 grams of water are stored per gram of glycogen in skeletal muscle. A study was conducted to examine the influence of moderate hypohydration (-5% of normal body weight) on muscle glycogen resynthesis and the subsequent effects on substrate utilization during one hour of cycling exercise. On two occasions, eight males completed two hours of intermittent cycling (60%-80% $\dot{V}O_2$ max) to lower muscle glycogen stores. During one experiment, cycling was followed by several hours of light upper-body exercise in the heat without fluid replacement to induce hypohydration (H) while, in the second experiment, water was ingested during the upper-body exercise/heat exposure in amounts adequate to maintain euhydration (E). Subjects then consumed 400 grams of carbohydrate and rested for 15 hours while maintaining the desired hydration state. The following morning, subjects performed one hour of cycling exercise (50% $\dot{V}O_2$ max) in a thermoneutral environment (18°C, 20% rh). Muscle wet/dry weight ratio was lower during H (3.65 ± 0.05) as compared with E (4.01 ± 0.04). Muscle glycogen resynthesis, however, was not different between experiments. During the one hour cycling exercise, muscle glycogen utilization, free fatty acid concentrations and respiratory exchange ratios were not different between experiments, while plasma glucose, lactate and glycerol levels were higher during H. These data indicate that, despite reduced muscle and body water availability, muscle glycogen resynthesis during the first 15 hours after heavy exercise is not altered by hypohydration. Further, moderate hypohydration does not appear to alter muscle metabolism during subsequent exercise performed in a neutral environment. However, hepatic metabolism may be impaired as indicated by higher plasma glucose, lactate and glycerol levels during H.

The importance of muscle glycogen stores for shivering was heretofore not demonstrated. Despite this lack of experimental evidence, one widely cited mathematical model of human thermoregulation bases its prediction of tolerance time in cold water on the rate of glycogen depletion in the skeletal muscle. The purpose of the present investigation was to study the importance of muscle glycogen for body temperature regulation during acute cold stress. The

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experimental aim was to measure thermoregulatory and metabolic responses during cold water immersion in resting euglycemic humans with high versus low muscle glycogen levels. It was hypothesized that the shivering and metabolic heat production would be impaired and body cooling in cold water would be greater when subjects were glycogen depleted. In addition, the experimental design offered an opportunity to determine whether or not a prolonged period of shivering during cold water immersion would result in a significant depletion of muscle glycogen stores in otherwise resting individuals. Eight euglycemic males were studied while they rested in cold (18°C, stirred) water on two separate occasions. The trials followed a three-day program of diet and exercise manipulation designed to produce either high (HMG) or low (LMG) pre-immersion glycogen levels in the muscles of the legs, arms and upper torso. Pre-immersion vastus lateralis muscle glycogen concentrations were lower during the LMG trial (144±14 mmol glucose•kg dry tissue^{-1}) than the HMG trial (543±53 mmol glucose•kg dry tissue^{-1}). There were no significant differences between the two trials in shivering as reflected by aerobic metabolic rate or in the amount of body cooling as reflected by changes in rectal temperature during the immersions. Post-immersion muscle glycogen levels remained unchanged from pre-immersion levels in both trials. It was concluded that thermoregulatory responses of moderately lean and fatter individuals exposed to cold stress were not impaired by a substantial reduction in muscle glycogen levels of several major skeletal muscle groups.

Tolerable encapsulation time in a Chemical Warfare Agent Protective Patient Wrap (dry insulative value = 1.44 clo; permeability index = 0.25; WRAP) was determined in four hot environments including a simulated solar heat load (1152 W•m^{-2}) for eight males. Mean body temperature (T_b), evaporative heat loss (EHL), dry heat gain (R+C), metabolic rate (M), and net heat flow (Msk) were measured or calculated from the heat balance equation. The ambient temperature ranged from 54.7°C (I) to 35.7°C (IV) and the relative humidity ranged from 17% (I) to 63% (IV). EHL ranged from 173.5 W•m^{-2} (IV) to 277.8 W•m^{-2} (I) at min 30 of encapsulation. R+C ranged from -129 W•m^{-2} (IV) to -230 W•m^{-2} (I) at that time and T_b averaged 37.6°C (IV) and 38.1°C (I). The average time of encapsulation ranged from 61.8 (IV) to 38.4 (I) min. A multiple linear regression equation to predict tolerable encapsulation was developed. These data show that tolerable encapsulation is severely limited in hot environments which have a marked solar heat load.

A preliminary study to determine whether a wettable cover would enhance evaporative heat loss (EHL) during encapsulation in the Chemical Warfare Agent Protective Patient Wrap was done (n=2). Encapsulation time in a hot dry

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environment with a simulated solar heat load (54.7°C/17%rh) was extended by some 23 min by covering the WRAP with wetted towels, thereby decreasing body heat storage by enhancing EHL from the surface of the WRAP.

To determine whether plasma volume dynamics were affected by the menstrual cycle five women were studied during exercise and passive heating. The exercise bout (80% $\dot{V}O_2$ peak on a modified cycle ergometer) and the passive heat stress were done in the same environment (T_a=50°C; Pw=1.6 kPa) during the follicular (F) and luteal (L) phase. Esophageal temperature (T_{es}) was measured continuously. Blood samples were drawn after each 0.2°C increase in T_{es} and $\dot{V}O_2$ was measured at that time. Initial PV was estimated at rest during F. PV changes from rest were calculated at each T_{es} from Hb and Hct. During passive heating, PV decreased to 2.83 l (-156 ml) in F. During L, there was a larger volume reduction (300 ml) during passive heating, and the final PV was lower than in F and averaged 2.47 l. During exercise, PV decreased 463 ml to 2.50 l in F and 381 ml to 2.50 l in L. These data indicate that there is a menstrual cycle effect on PV dynamics during passive heating such that more fluid is shifted out of the vasculature during the luteal phase. During severe exercise there is a greater fluid loss during the follicular phase, yet the final PV is not different between phases.

A rational effective temperature (ET*) was derived using a psychrometric format to assess the relative thermoregulatory strain occurring during moderate exercise (T_a=30.2°C; P_w=1.0 kPa) caused by antidotal treatment for organophosphate poisoning. Atropine plus pralidoxime treatment increased ET* by 4.1°C as compared to saline treatment while atropine or pralidoxime alone increased ET* by 2.0°C. These data indicate that antidotal treatment for organophosphate poisoning significantly increased thermoregulatory strain during exercise than occurred with either drug alone.

A prototype of the currently fielded microclimate air vest system, redesigned for air crews, was evaluated on its ability to reduce heat stress in humans exercising at 436 watts in 45°C db, 23°C dp and 35°C db, 29°C dp environments. Air was provided to the systems at 30, 40 and 45°C db with 20% rh, and 35°C db with 70% rh. Air was provided at flow rates of 5 and 7 l•min^{-1}. Data analysis is complete on the low humidity tests and ongoing on the high humidity data. Low humidity results show that endurance time with no cooling and at 45°C and 7 l•min^{-1} are significantly less than with air provided at 30°C at both flow rates. Sweating rates were significantly greater with no cooling than with

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air provided at any temperature or flow rate, but there was no increase in evaporative cooling found with the air systems. The systems appear to provide a significant benefit due to increased convective cooling with air provided at a sufficiently low dry bulb.

Load carriage systems supported by the trunk have been shown to decrease certain indices of pulmonary function. We investigated the hypothesis that these pulmonary function reductions are directly related to the backpack load carried due to the mechanical constraint it imposes on the thoracic cage. To investigate this hypothesis, five young males with no pulmonary disorders were tested while standing upright carrying well-fitted 0, 10 or 30 kg loaded U.S. Army ALICE backpacks. Forced vital capacity (FVC), forced expiratory volume (FEV_1) and 15 s maximal voluntary ventilation (MVV_{15}) were measured. With increased load, FVC and FEV_1 progressively decreased reaching 6 and 6.7% decrements respectively, with the 30 kg load. The MVV_{15} was decreased by about 8.4% with the 10 kg load, but did not demonstrate any further decrement with the 30 kg load. Analysis of flow-volume loops obtained with the 0 and 30 kg loads showed that the reduction of FVC was not associated with any decrement of peak inspiratory or expiratory flows. These results indicate a limitation on the ventilatory pump caused by load carriage which is directly related to the load carried and characteristic of restrictive disease of the respiratory system (reduced FVC and FEV_1 with no decrement in FEV_1/FVC).

Overall sense of effort during muscular exercise has been described to have local and central components. Both components are thought to be involved in the determination of rated perceived exertion (RPE) and constant effort (CE) during physical exercise; however, RPE and CE have not been directly compared. The present study examined the relationship between RPE during steady-state exercise and CE during CE exercise in 10 male volunteers. Steady-state exercise (~60% peak $\dot{V}O_2$) and CE exercise (initial exercise intensity ~70% peak $\dot{V}O_2$) were each performed for 30 minutes on a cycle ergometer. During steady-state exercise, RPE increased as the exercise duration increased. During CE exercise, power output (W) decreased as exercise duration increased. When W during CE exercise was plotted as a function of RPE during steady-state exercise for identical time intervals, the following linear relationship (y=bx+a) was obtained: W=b•RPE+a where a is 196.6 and b is -3.14 (r = -0.47). These findings indicate that RPE and CE are related; and, when studied collectively, may someday help explain the mechanism(s) responsible for the buildup of muscular fatigue during physical exercise.

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Localized cutaneous vasodilation (flush) is seen following systemic atropine administration. To verify calculated enhanced dry heat loss with actual changes in cutaneous blood flow, four men were studied in both control and atropine (0.025 mg•kg^{-1};im) experiments (T_a = 30°C, T_{dp} = 7°C) during moderate exercise (55% $\dot{V}O_2$ peak). Esophageal temperature (T_{es}) and arm sweating ($\dot{m}_s$) by local dewpoint were measured continuously. Skin (forearm) blood flow (FBF) was measured twice each minute by venous occlusion plethysmography. Injection of atropine (2 mg) caused an increased sensitivity (±85%, P<0.01) in FBF to T_{es} with no change in the vasodilator threshold. An elevated T_{es} onset (0.3°C, P<0.05) for sweating occurred with no change in the sensitivity of $\dot{m}_s$ to T_{es} (-27%, P<0.20). No elevation in either forearm or T_{sk} occurred before the onset of vasodilation; however, both mean skin (T_{sk}) and local arm temperatures were higher in the atropine experiments after 15 min of exercise. Systemic atropine resulted in higher cutaneous vasodilation at the same core temperature with the local skin temperature following passively. The effect of systemic atropine in stimulation of increased cutaneous vasodilation is suggested to result by a combination of central and local responses which may be mediated through the release of vasoactive substances.

A tightly controlled laboratory study was performed in which the thermoregulatory effects of an intramuscular injection of atropine sulfate (2 mg) were compared with a placebo injection of sterile saline during exposure to a cool environment. Four subjects were tested during seated cycle exercise at a moderate intensity (55% $\dot{V}O_2$ peak) at an ambient temperature of 22°C (37% relative humidity; ambient water vapor pressure 1.0 kPa). Esophageal temperature (T_{es}), mean weighted skin temperature (T_{sk}), and forearm sweating rate ($\dot{m}_s$) were continuously measured during 30 min of rest and 35 min of exercise. Skin blood flow (FBF) from the forearm was measured twice each minute by venous occlusion plethysmography. Whole-body sweating was calculated from weight changes pre- and post-exercise. The expected decrease in whole-body and local sweating rate (-57% and -65%, respectively) occurred in the atropine-treated subjects. By 10-15 min of exercise, dry heat loss (R + C, radiative and convective heat exchange) was significantly elevated from the head, chest, back, arm, forearm and thigh in the atropine experiments. Core temperature actually decreased 0.2°C (P<0.05) in the atropine-treated subjects during exercise as a result of enhanced dry heat exchange. By 25 min of exercise, FBF was 98% (P<0.05) greater after atropine treatment. These results show that the peripheral modification of cutaneous blood flow which occurs in atropine-treated subjects is sufficient to markedly alter heat exchange in a cool environment.

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Thermoregulatory responses during heat acclimation were compared between nine young (mean age 21.2 yr) and nine middle-aged men (mean age 46.4 yr) who were matched ($P>0.05$) for body weight, surface area, surface area-to-weight ratio, percent body fat, and maximal aerobic power. After evaluation in a comfortable environment (22°C, 50% relative humidity), the men were heat acclimated by treadmill walking (1.56 m/s, 5% grade) for two 50-min exercise bouts separated by 10 min of rest for 10 consecutive days in a hot dry (49°C ambient temperature, 20% relative humidity) environment. During the first day of heat exposure, performance time was 27 min longer ($P<0.05$) for the middle-aged men, whereas final rectal and skin temperatures and heart rate were lower, and final total body sweat loss was higher ($P<0.05$) compared with the young men. These thermoregulatory advantages for the middle-aged men persisted for the first few days of exercise-heat acclimation ($P<0.05$). After acclimation no thermoregulatory or performance time differences were observed between groups ($P>0.05$). Sweating sensitivity, esophageal temperature at sweating onset, and the sweating onset time did not differ ($P>0.05$) between groups either pre- or post acclimation. Plasma osmolality and sodium concentration were slightly lower for the young men both pre- and postacclimation; however, both groups had a similar percent change in plasma volume from rest to exercise during these tests. Final rated perceived exertion was generally higher ($P<0.05$) for the young men throughout the acclimation period, whereas final thermal sensation was higher ($P<0.05$) only on the first acclimation day. Greater regular weekly aerobic activity for the middle-aged men was associated with their better initial performance during exercise in the heat; however, heat acclimation negated this advantage. Evidence from the present study indicated little impairment of the thermoregulatory system at least through the fifth decade of life for physically trained middle-aged men.

Thermal insulation and vapor permeability characteristics accompanied with specific prediction modeling of tolerance times at various environmental and work rate scenarios and with different Military Oriented Protective Postures were completed and provided as best approximation strategy for the screening of aerosol-agent protection and heat stress trade-offs in military personnel.

A copper man evaluation and heat stress model prediction encompassing four prototype International Material Evaluation (IME) lightweight CB garments was completed. One IME garment (MK IV) that provided moderate evaporative

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potential compared to its thermal resistance and the highest maximal work times will be evaluated in a comprehensive human biophysical protocol in 1989.

A microclimate cooling model was developed for use in a desk-top computer that predicts effectiveness of air-cooled vests in reducing heat stress while wearing impermeable chemical protective clothing. The model allows prediction of rest times and heat storage rates based on heat transfer of the clothing and the air-cooled vests, either separately or in concurrent mode, and prevention of frank overcooling while resting. The model was used this CY 88 in an evaluation for aircrew personnel while wearing MOPP 4 overgarments.

Prototype Combat Gloves (CG) were evaluated in a human biophysical protocol designed to test tolerance limits at an ambient temperature of -10 °C while soldiers are resting or marching (3.5 mph). The CG are lined with waterproof/breathable membranes (consisting of polyurethane, polyethylene, and polytetra-fluoro-ethylene) designed for use in cold climates along with the Extended Cold Weather Clothing System (ECWCS). Subject endurance times were well below maximal limits (120 min) of the standard Arctic mitten when the prototype items were wet or in elevated winds (up to 5 $m \cdot s^{-1}$).

Another study was completed focusing on the efficacy of a prototype Combat Vehicle Crewman (CVC) glove specifically for use in the cold with the CVC uniform. Subjects participated in two activities; walking at 1.34 $m \cdot s^{-1}$ or operating a contact simulator. This simulator consists of a liquid-filled envelope mounted on a stand. When subjects push against the envelope, a pressure sensitive switch operates a timer, indicating that subjects are maintaining contact with the envelope which is maintained at chamber temperature. Subject endurance times at -6.7 and -15°C (2.2 $m \cdot s^{-1}$) were equal or significantly better for subjects wearing the CVC glove versus the two-layer light duty glove.

A new "sweating" flat plate with environmental box for measuring thermal resistance and vapor impedance of military fabrics was received and assembled in the physics laboratory. A database of combat textiles has been initiated. Comparison with NATO fabric values is now a possibility this Division will pursue along with standardization of thermal values. This is the only laboratory in the USA with a Hohenstein sweating flat plate.

The current emphasis in handwear development is on retaining insulation in a wet environment. A new aluminum, 9-section field portable thermal hand was

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purchased and tested in CY88. The model is "weatherproof" that will allow the direct biophysical evaluation of wet handwear insulation; a capability that did not exist prior to this purchase. The aluminum hand will also serve as an interim replacement for the 23-section articulated thermal hand model which is obsolete and at present inoperative.

Thermal insulation of footwear is measured on a copper thermal foot model. In CY88, prototype boots for extreme cold and cold-wet climates were evaluated, including a vapor barrier (VB) boot modified for ski use. Other boots tested incorporated innovations such as poly-tetra-fluoro-ethylene (PTFE) moisture barriers, microfiber insulation and radiant barriers. The standard combat boot was tested with commercial insole. Biophysical evaluations for 15 footwear items were completed in CY88.

A field portable meteorological station for the collection of air and ground temperatures, wind speed and solar radiation was assembled in support of a nutrition/altitude study at the Marine Corps Mountain/Winter Warfare Center. The system also incorporated a battery-powered data logger. Components of the system were selected and prepared for use in a sub-zero environment. A program for data acquisition was written and an informal operation manual was written for the operator. Assistance was also provided for transfering the data to the mainframe computer and some data analysis after the study.

The relationship between barometric pressure (Pb) and convective heat transfer (hc) was studied using a copper man in the USARIEM altitude chamber. We found that hc varied linearly with Pb; hitherto the relationship was thought to be a power function. In a hypobaric environment, a linear dependency reveals a overestimation of the convective heat loss and an underestimation of the clothing insulation value by the power function computation.

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ABSTRACTS:

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ABSTRACTS:

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Young, A.J., P.D. Neufer, R.L. Hesslink and J.T. Reeves. Muscle fiber size in lowland residents before and after altitude acclimatization. Physiologist 31:146, 1988.

PRESENTATIONS:

Endrusick, T.L. and R.R. Gonzalez. Physiological responses while wearing military clothing and handwear in cold environments. Third International Environmental Ergonomics Conference, Helsinki, Finland, August 1988.

Levell, C.A. and R.R. Gonzalez. Heat transfer properties of chemical protective overgarments with variable permeation properties. Third International Environmental Ergonomics Conference, Helsinki, Finland, August 1988.

Nielsen, R. and T.L. Endrusick. The role of knit structure in underwear on thermoregulatory responses to intermittent exercise. Third International Environmental Ergonomics Conference, Helsinki, Finland, August 1988.

Pandolf, K.B. Heat and cold stress: Thermoregulatory mechanisms. Paper delivered as part of panel entitled, Aeromedical Aspects of Survival, 59th Annual Scientific Meeting of the Aerospace Medical Association, New Orleans, LA, April 1988.

Pandolf, K.B. Environmental physical stress: High altitude, and cold and heat. Lecture as part of advanced course entitled, Fitness of the Army. U.S. Army War College, Carlisle Barracks, Pennsylvania, April 1988.

Pandolf, K.B. Human performance in the heat, cold and at altitude. Exercise Science Seminar Series, Concordia, Montreal, Quebec, Canada, October 1988.

Pandolf, K.B. Human performance at the environmental extremes of heat and cold. Seminar at the Defence and Civil Institute of Environmental Medicine, Downsview, Ontario, Canada, October 1988.

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PRESENTATIONS:

Pandolf, K.B. Thermal adjustments to endurance exercise in the heat. Presentation before the Greater New York Regional Chapter of the American College of Sports Medicine, Queens College, Flushing, New York, October 1988.

Santee, W.R. and J.M. McGrath. Contact simulation devices for handwear evaluation. Third International Environmental Ergonomics Conference, Helsinki, Finland, August 1988.

KEY BRIEFINGS:

Richard R. Gonzalez, Ph.D. MOPP studies, the problems with heat acclimation with and without MOPP 4, sweating techniques, robotic models, ARIEM'S heat stress model, heat stress casualties and methods to cool the soldier; ACSD special briefing to Chairman, (Professor M. Meselson, Harvard University) Board of Army Science and Technology Panel, Natick, MA, 10 March 1988.

Richard R. Gonzalez, Ph.D. Heat transfer and biophysics of clothing materials; Board of Army Science and Technology Panel (BAST), USARIEM, Natick, MA, 20 June 1988.

Richard R. Gonzalez, Ph.D. Biophysics of heat transfer through MOPP clothing; Dusty Agents Action Working Group, Natick, MA, 4 August 1988.

Clement A. Levell Heat stress prediction in prototype lightweight chemical garments; IPD/TROSCOM Working Group, Natick, MA, 14 July 1988.

Clement A. Levell Heat stress in chemical protective garments; Dusty Agents Action Working Group, Natick, MA, 10 October 1988.

Kent B. Pandolf, Ph.D. Finalization of O&O Plan for family of heat stress monitors; USAMMDA, Frederick, MD, 11 August 1988.

Michael N. Sawka, Ph.D. Microclimate cooling to reduce thermal stress in soldiers; National Research Council Review Panel, USARIEM, Natick, MA, May 1988.

Michael N. Sawka, Ph.D. Cardiovascular mechanisms during muscular exercise; Massachusetts General Hospital, Boston, MA, December 1988.

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KEY BRIEFINGS:

Lou A. Stephenson, Ph.D. Human research effort regarding pre-treatment and antidotes to organophosphate poisoning; Israel Defence Forces delegation, USARIEM, Natick, MA, July 1988.

Andrew J. Young, Ph.D. Physiological considerations for cold water immersion and rewarming; Naval Medical Research Institute, Bethesda, MD, 1 April 1988.

Andrew J. Young, Ph.D. Structural and functional aspects of human skeletal muscle physiology; Clinical Applications of Exercise Physiology Class (Graduate Program in Physical Therapy), Masachusetts General Hospital, Boston, MA, September 1988.

SIGNIFICANT TDY:

Thomas L. Endrusick To the Hohenstein Institute, Bonnighheim, FRG to observe the Clothing Physiology Laboratory which conducts estensive textile research for the EEC and NATO, August 1988.

Richard R. Gonzalez, Ph.D. To the American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE), Dallas, TX to serve as Chairman of Symposium on Mathermatical Modelling in Diverse Environments, February 1988.

Richard R. Gonzalez, Ph.D. To Brooks Air Force Base, San Antonio, TX to discuss Heat Stress Modeling and Properties of Air Crew Clothing, February 1988.

Richard R. Gonzalez, Ph.D. To Defence Civil Institute Environmental Medicine, Downsview, Canada to review their plans for environmental chambers and discuss thermoregulatory modeling schemes, July 1988.

Clement A. Levell and Leander A. Stroschein To Wright-Patterson Air Force Base, Dayton, OH to discuss heat stress modeling results of aircrew personnel, April, 1988.

Kent B. Pandolf, Ph.D. Final meeting concerning publication of Institute book entitled, Human Performance Physiology and Environmental Medicine at Terrestrial Extremes, Benchmark Press Inc., Indianapolis, IN, 7 March 1988.

MILITARY ERGONOMICS DIVISION

SIGNIFICANT TDY:

William R. Santee, Ph.D., Thomas L. Endrusick and Clement A. Levell To the 3rd International Environmental Ergonomics Conference, Helsinki, Finland, August 1988.

Michael N. Sawka, Ph.D. To National Aeronautics and Space Administration, Ames Research Center, Moffett Field, CA to present on the effects of erythrocyte infusion on exercise performance and temperature regulation, March 1988.

Michael N. Sawka, Ph.D. To New York Regional Meeting of the American College of Sports Medicine, New York, NY to present on the influence of hydration and body fluids on exercise performance in the heat, October 1988.

Michael N. Sawka, Ph.D. To Letterman Army Institute of Research, San Francisco, CA to present on acute polycythemia effects on blood volume and exercise performance, December 1988.

Andrew J. Young, Ph.D. To Air Standardization Coordinating Committee Meeting, Pensacola, FL to participate as the U.S. Army Representative, April 1988.

Andrew J. Young, Ph.D. To P^2NBC^2, TSAG Meeting, Fort McClellan, AL to participate as the USARIEM Representative, June 1988.

Andrew J. Young, Ph.D. To P^2NBC^2 Expert Panel Meeting, Atlanta, GA to participate as USARIEM Representative, June 1988.

SIGNIFICANT VISITORS:

David W. Bennett, Technical Leader Robotics and Remote Systems, Batelle Northwest Laboratories, Richland, WA.

F. Timothy O'Neill, Vice President, Measurement Technology, Seattle, WA.

Hannu Anttonen, Chief of Industrial Hygiene Section, Oulu Regional Institute of Occupational Health, Oulu, Finland.

T.M. Moynehan, Director, Stores and Clothing Research and Development Establishment, Ministry of Defence, Colchester, UK.

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SIGNIFICANT VISITORS:

Sam Brinton, Chief Research and Product Development, W.L.Gore and Associates, Three Blue Ball Rd., Elkton, MD.

Karl Heinz Umbach, Chief Scientist, Forschungsinstitut Hohenstein, D-7124, Bonnigheim, Federal Republic of Germany.

LTC Dr. Zelig Techner, LTC David Friedman, Drs. Aharon Levy and Zeev Tashma, Medical Corps, Israel Defence Forces, Israel.

CPT Rajinder Singh and Messrs. C. Manohara, Lee Meng Boon, Soo Kok Tiong and Peter Kuok, Singapore Armed Forces Team, Singapore.

PROFESSIONAL APPOINTMENTS/ACTIVITIES:

Richard R. Gonzalez, Ph.D., Adjunct Professor, Environmental Science and Physiology, Harvard School of Public Health, Harvard Medical School, Boston, MA.

Richard R. Gonzalez, Ph.D., Standards Preparation Committee (SPC 55-81R) Member, American Society of Heating, Refrigeration and Air Conditioning Engineers.

Kent B. Pandolf, Ph.D., Adjunct Professor of Health Sciences, Department of Health Sciences, Sargent College of Allied Health Professions, Boston University, Boston, MA.

Kent B. Pandolf, Ph.D., Adjunct Professor of Environmental Medicine, Springfield College, Springfield, MA.

Kent B. Pandolf, Ph.D., Editor, Exercise and Sport Sciences Reviews.

Kent B. Pandolf, Ph.D., Editorial Board Member, Medicine and Science in Sports and Exercise.

Kent B. Pandolf, Ph.D., Editorial Board Member, Ergonomics.

Michael N. Sawka, Ph.D., Adjunct Associate Professor, Department of Physical Therapy, Sargent College of Allied Health Professions, Boston University, Boston, MA.

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PROFESSIONAL APPOINTMENTS/ACTIVITIES:

Michael N. Sawka, Ph.D., Adjunct Associate Professor, Department of Physical Therapy, Institute of Health Professions, Massachusetts General Hospital, Boston, MA.

Michael N. Sawka, Ph.D., Position Statement Committee Member, American College of Sports Medicine.

C. Bruce Wenger, M.D., Ph.D., Visiting Research Associate in Physiology, Harvard School of Public Health, Harvard Medical School, Boston, MA.

C. Bruce Wenger, M.D., Ph.D., Member, Working Group 11, Subcommittee C95.1-IV, American National Standards Institute.

Andrew J. Young, Ph.D., Chairman, Public Information Committee, American College of Sports Medicine.

MILITARY NUTRITION RESEARCH DIVISION

SIGNIFICANT RESEARCH FINDINGS/DEVELOPMENTS:

A field ration trial was conducted at the Marine Corps Mountain Warfare Training Center, Bridgeport, CA to determine which of three new military field rations would be most appropriate for cold weather moderate altitude operations. An 11-day field test comparing the Improved Meal, Ready-To-Eat (IMRE), the Ration, Cold Weather (RCW), and the Ration Lightweight (RLW) was conducted during the second two weeks of a six week Marine Mountain Leaders Course taught at the Marine Corps Mountain Warfare Training Center, Bridgeport, CA. This testing site was selected because the environmental conditions and physical training regimen required substantial energy expenditures. Food and water intakes, hydration status, body weight changes, blood chemistries, and ration acceptability were recorded. Although all three groups lost a significant amount of body weight (3.3-4.4%), the differences between groups were not significant. Adequate water was available; mean fluid intakes were 5.3±0.3, 5.3±0.3, and 4.7±0.2 L water/man/day for the IMRE, RCW, and RLW groups, respectively. The mean urine specific gravities for each ration group were below 1.020. These findings suggest that all three groups were adequately hydrated. The results indicate that all three rations were suitable for moderate altitude cold weather operations, however none proved to be superior to the others in reducing weight loss, or in increasing caloric or water intake. Although it is susceptible to freezing and is heavier, the improved MRE was just as effective as the dehydrated Ration, Cold Weather (RCW). The RCW was the better choice if weight and volume considerations were important. The Ration, Lightweight (RLW) (if issued in a double module) was satisfactory for cold weather operations, although the MRE or RCW would be preferred choices.

A cold weather ration test was also conducted with the 6th ID At Fort Wainwright, Alaska. The results of this test emphasized the importance of proper soldier training and equipment for effective use of the Ration Cold Weather (RCW) in a cold environment. Two squads of Light Infantry volunteered to test the role of water consumption on consumption of the RCW. One squad was encouraged to drink at least 4 L/man/day (Group 1) while the other served as the control (Group 2). The test was conducted in February 1988 in conjunction with the 6th ID winter warfare training (Callous Warrior). Pre and post measurements were taken along with daily monitoring of food intake, water intake, body weight, and hydration status. Both groups consumed water in excess of 3 L/man/day and their hydration status could be describe as high normal (elevated specific gravity and decreased sodium/potassium ratios). There were no significant differences in the energy intakes of the 2 groups, but they only consumed 54% of the energy required (4700 kcal) to maintain body weight (Group 1 lost 3.2% and Group 2 lost 4.1%). Group 1 and 2 consumed an

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SIGNIFICANT RESEARCH FINDINGS/DEVELOPMENTS:

average of 2734 and 3029 kcal/day, respectively. The main reason for periods of low consumption was the lack of hot water for hydrating ration components when the Yukon stove was not operating. The results of this study indicate that zinc and folacin need to be increased in the RCW. To use the RCW as a stand alone ration for the Light Infantry, modifications are necessary in the delivery of water and in methods of heating water to allow individuals to produce hot water. Water consumption needs to be encouraged and containers issued to allow the troops to carry water inside their clothing to prevent freezing.

A garrison dining facility menu modification study was conducted at Fort Devens, MA. This study was planned as a passive nutrition intervention study in an attempt to moderate soldiers high intakes of cholesterol at the breakfast meal. This study was conducted in response to a tasking from the Office of the Deputy Chief of Staff for Logistics (ODCSLOG) and is the fourth in a continuing series of nutrition assessments of soldiers subsisting in garrison dining facilities. Nutrient intakes were evaluated by comparing average daily nutrient intakes expressed as group means, with the Office of the Surgeon General (OTSG) Military Recommended Dietary Allowances (MRDA AR 40-25). Previous garrison dining facility nutrition studies results indicated that test subjects average daily cholesterol intakes were at least two times the levels (<300mg/day) recommended by the American Heart Association, the National Cholesterol Education Program and others. Fifty to sixty percent of total daily cholesterol was obtained at breakfast meals with egg entrees contributing 70% to 80% of breakfast cholesterol. On four days of the eight day garrison dining facility passive nutrition intervention study, a commercially available low cholesterol egg product was mixed with one egg (versus the two usually used), for scrambled egg and omelet entrees. This reduced the cholesterol obtained from scrambled egg and omelet entrees from 272 ± 117 mg to 135 ± 34 mg, respectively, which was statistically significant ($P<0.01$). Total breakfast cholesterol which includes all foods consumed at the breakfast meal that contain cholesterol, eg., breakfast meats, etc., was reduced by 141 mg (427 ± 117 mg to 286 ± 133 mg) and was also statistically significant ($P<0.01$). Average daily cholesterol intakes were reduced by 108 mg (749 ± 238 mg vs 641 ± 240 mg) on the four intervention days using the low cholesterol egg product and one egg. Hedonic rating data indicated no difference in acceptability for the scrambled egg and omelet entrees prepared with one egg and 2 ounces of low cholesterol egg product compared to the usual scrambled egg and omelet entrees. Nutrient intakes of the Ft. Devens II test subjects met or exceeded the MRDA for energy, protein, vitamins, and minerals. Sodium intakes for the test subjects of 1709 mg/1000 kcals were slightly above

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the OTSG guidelines of 1400-1700 mg sodium per 1000 kcals. Approximately 9% of total sodium was obtained from salt added by the test subjects. Test subjects fat intakes of 40.3% were approximately five percent higher than what was reported for similarly aged males in the 1985 Nationwide Food Consumption Survey and exceeded the MRDA target level of 35% (maximum) of total calories. Cholesterol intakes of test subjects were at least two to two-and-one-half times higher than what civilian cholesterol standards recommend (<300 mg/day). The study demonstrates that low-cholesterol egg substitutes were acceptable to patrons and significantly reduced dietary cholesterol intakes at the breakfast meal.

Two colored, flavored, 2.5% carbohydrate-electrolyte solutions (Armyade and NBC Nutrient solution) with varying levels of magnesium, potassium, and phosphorus were tested for ad libitum consumption and acceptability during 8 days of work in a hot environment at Ft. Hood, TX, (max t_{amb}=31-38°C). Sixty-one male and female soldiers were divided into 4 test groups. A Control group drank water while the remaining three groups were given one of the following test beverages: NBC Nutrient solution, Armyade, or a colored flavored water (placebo). All four groups were allowed to consume other fluids such as plain water, soda, juice, etc. Acceptability in terms of hedonic ratings and consumption rate was determined. There were no group differences in term of energy intake. The subjects in the NBC group had a significantly higher ($p<0.001$) average daily fluid intake than those in the Armyade group, but their intake was not significantly greater than that of the soldiers in the Control (water) or Placebo groups. The hedonic ratings of acceptability did not decrease with ad libitum ingestion during the 8 days. On a daily basis, the subjects in the in the NBC and Placebo groups rated their test beverages as more acceptable than the water rated by the Control group, drank more of these test beverages than water, and had lower incidences of hypohydration. The NBC and Placebo beverages were effective in reducing the incidence of hypohydration by enchancing fluid intake during field exercises in hot climates. When food intake is adequate, the carbohydrate-electrolyte beverages are not necessary to provide electrolytes but may be helpful in improving fluid intake. According to the clinical chemistries, ingestion of the carbohydrate-electrolyte solutions was not accompanied by deviation from physiologically normal values. Drinking NBC and Armyade solutions appeared to be safe under the conditions studied.

A cardiovascular risk assessment and garrison dining facility dietary evaluation study conducted on basic trainees at Fort Jackson, SC showed that young recruits are in good cardiovascular status during their initial

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SIGNIFICANT RESEARCH FINDINGS/DEVELOPMENTS:

introductory phase of Army training. The incidence of blood cholesterols above 200 mg/dl was extremely low. However, cholesterol intakes in the dining hall were over twice the American Heart Association recommended guidelines. Fat intake, on the other hand, was below the target value of 35% of the calories. The mean total serum cholesterol level for males (mean age 19) was 140±24 mg/dl (Mean±SD) and for females (mean age 20) 162±28 mg/dl. Although these serum cholesterol levels appear low, they may be somewhat misleading due to an "adolescent drop" in serum cholesterol levels often found in 16-20 year olds. Serum cholesterol levels between 200-239 mg/dl were found in 3 of the 125 males (3%) and 11 of the 126 females (9%). Serum cholesterol levels above 239 mg/dl were not observed. Blood lipid profiles were determined for 40 males and 39 females. Males has a mean total cholesterol (TC) level of 149 mg/dl (mean±SD), mean LDL cholesterol (LDL-C) levels of 92±27 mg/dl, and mean HDL cholesterol (HDL-C) levels of 51±12 mg/dl. Females had mean TC levels of 165±26 mg/dl, mean LDL-C levels of 98±25 mg/dl, and HDL-C levels of 59± mg/dl. The mean TC/HDL-C and LDL-C/HDL-C ratios were 3.50 and 1.93 for males and 2.87 and 1.73 for females. These basic trainees were consuming diets which met or exceeded the Military Recommended Dietary Allowances (MRDA) for energy, protein, vitamins, and minerals. However individually, many females did not meet the MRDA for calcium (47%), Vitamin B_{12} (30%) and iron (50%). Many of these inadequate intakes (i.e., nutrient intakes below the MRDA) were the result of low consumption of dairy products, eggs, and other animal products. These inadequate intakes were especially noted for females consuming total fat intakes between 25-29% of calories as fat (%FAT). Both the male and female mean total dietary fat intakes for seven days were 34%FAT. This was the first sample of soldiers to achieve the Army's goal of total fat intakes less than 35%FAT. The absence of a short order line and limitations on high fat, high calorie bakery items (donuts, pastries, etc.) may have assisted in the attainment of this goal. Significant differences ($p<0.05$) were determined between the cholesterol intakes of males and females (males 225±68mg/1000 kcal, females 170±83 mg/1000 kcal). Mean cholesterol intakes were 703±208 mg/day for males and 418±219 mg/day for females. This significant difference in cholesterol intake was directly attributale to decreased consumption of eggs and other high fat meats by females in general. Mean sodium intakes were above the MRDA upper limit of 1700 mg/1000 kcal (males 1856 mg/1000 kcal, females 1819 mg/1000 kcal). These sodium intakes were generally higher than those reported for other USARIEM studies. These data suggest that nutrition initiatives which have focused on the frequency with which high fat, high sodium menu items are served or those aimed at reducing the fat and sodium content of existing recipes may have achieved their maximum results. Continued efforts along these lines without the introduction of new menu items or ingredients to the Army feeding system may meet with minimal success. The

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SIGNIFICANT RESEARCH FINDINGS/DEVELOPMENTS:

objectives of future nutrition initiatives should not be to reduce fat, cholesterol, and sodium intake by taking away foods, but rather, to develop highly acceptable and palatable menu items which also have the added benefit of being low fat, low in cholesterol, and lower in sodium.

PUBLICATIONS

Askew, E.W. Nutrient requirements for high-stress environments. Activities Report of the R and D Associates. Published by the Research and Development Associates for Military Food and Packaging Systems, Inc. San Antonio, TX 40:(2)104-110, 1988.

Morgan, T.E., L.A. Hodgess, D. Schilling, R.W. Hoyt, E.J. Iwanyk, G. McAninch, T.C. Wells, V.S. Hubbard, and E.W. Askew. A comparison of the meal, ready-to-eat, ration, cold weather, and ration, lightweight nutrient intakes during moderate altitude cold weather field training operations. USARIEM, Technical Report T/5, 1988.

Rose, M.S., C.S. Houston, C.S. Fulco, G. Coates, J.R. Sutton, and A. Cymerman. Operation Everest II: nutrition and body composition. J Appl Physiol, 65:2545-2551, 1988.

Rose, M.S., R.P. Francesconi, L. Levine, B. Shukitt, A.V. Cardello, P.H. Warren, I. Munro, L. Bandaret, P.M. Poole, P. Frykman, and M. Sawka. Effects of a NBC solution on physiological and psychological status during sustained activity in the heat. Proceedings of the Army Science Conference, 2:555-569, 1988.

Rose, R.W., T.E. Morgan, M.S. Rose, S.R. Srinivasan, G.S. Berenson, and E.W. Askew. Population screening for blood lipid levels and related coronary heart disease risk factors among U.S. Army basic trainees. USARIEM, Technical Report T/2, 1988.

Smith, D.J. and J.S.A. Edwards. Nutrient requirements and recommendations for military personnel. Institute of Naval Medicine, Gosport, United Kingdom. INM Report No. 25/88, 1988.

Szeto, E.G., T.B. Dugan, and J.A. Gallo. Assessment of habitual diners nutrient intakes in a military-operated garrison dining facility Ft. Devens I. USARIEM, Technical Report T/3, 1988.

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NUTRITION RESEARCH DIVISION

ABSTRACTS

Askew, E.W., M.A. Sharp, M.S. Rose, K. Reynolds, R.W. Hoyt, and C.P. Shaw. Physical performance capacity of soldiers after 30 days of moderate energy restriction. FASEB J. 2:A1224, 1988.

Delany, J.P., D.A. Schoeller, and R.W. Hoyt. Use of doubly labeled water (DLW) to measure energy expenditure of special operations soldiers during a four week field training exercise. FASEB J. 2:A1225, 1988.

Levine, L., M.S. Rose, R.P. Francesconi, and M.N. Sawka. Fluid replacement during sustained activity in the heat: nutrient solution vs water. Aviat. Space & Environ. Med. 59:479, 1988.

Matthew, W., G. Thomas, M. Rose, R. Hubbard, R. Whang, F. Schatzle, J. Baldwin, S. Hsu, O. Huh, and F. Quirk. Satellite remote-sensing of heat stress during reserve training at Ft. Hood. Proceedings of the 9th Annual Electro-Optical Systems Atmospheric Effects Library/Tactical Weather Intelligence, Dec 1988.

Rose M.S., R. Francesconi, and L. Levine. Effects of a nutrient solution on nutritional status during sustained activity in the heat. FASEB J. 2:A1223, 1988.

Young, A.J., M.N. Sawka, P.D. Neufer, S.R. Muza, J.E. Bogart, J.C. Buchbinder, and K.B. Pandolf. Thermoregulation during cold water immersion is unimpaired by muscle glycogen depletion. FASEB J. 2:A935, 1988.

PRESENTATIONS:

Askew, E.W. Carbohydrate supplementation of a military field ration for work at high altitude. Commonwealth Defense Science Organization Conference. Kuala Lumpur, Malaysia, 27 Jan 88.

Askew, E.W. New operational ration development in the United States. Commonwealth Defense Science Organization Conference. Kuala Lumpur, Malaysia, 27 Jan 88.

Askew, E.W. Nutrient requirements for a high stress environment. Research Development Associates Meeting. San Antonio, TX, 21 Apr 88.

Askew, E.W. Nutrition for environmental extremes. USARIEM Current Concepts in Environmental Medicine Course. Natick, MA, 17 May 88.

MILITARY NUTRITION RESEARCH DIVISION

PRESENTATIONS:

Askew, E.W. Nutrition for environmental extremes. Massachusetts Dietetic Association. Natick, MA, 8 Sept 88.

Askew, E.W. Practical aspects of cold weather nutrition. Marine Corps Mountain Warfare Training Center, Field Grade Officers Training Course. Bridgeport, CA, 14 Dec 88.

Askew, E.W. Military nutrition research initiatives. Association of Military Surgeons. San Antonio, TX, 2 Nov 88.

Morgan, T.E. Planning a healthy diet: How to reduce fat and cholesterol. 1988 Federal Women's Program. Natick, MA, Jan 88.

Morgan, T.E. Effects of dietary fat level on physical performance. New England Chapter, American College of Sports Medicine. Worcester, MA, Oct 88.

Rose, M.S. Current research in Military Nutrition. NBC Nutrient Solution Test. AMSC ML Hamrick Research Course. Leesburg, VA, Aug 88.

Rose, M.S. NBC Nutrient Solution use in the heat. USARIEM Current Concepts in Environmental Medicine Course. Natick, MA, 17 May 88.

KEY BRIEFINGS

Eldon W. Askew, LTC, Ph.D. Military ration field testing; Sub-Committee on Research and Technology of the Army Food 2000 Task Force, FED, USANRDEC, Natick, MA Sep 1988.

Eldon W. Askew, LTC, Ph.D. Overview of nutrition initiatives; COL Henry T. Glisson, Chief, Troop Support Division, DA DCSLOG, Natick, MA Aug 1988.

Eldon W. Askew, LTC, Ph.D. Support to Ration RDTE; MG John E. Long, Commanding General, TROSCOM, Natick, MA Dec 1988.

Eldon W. Askew, LTC, Ph.D. Ration testing and ration design; Special Forces Operational Command, Fort Bragg, NC 23 May 1988.

Eldon W. Askew, LTC, Ph.D. FY88 Marine Corps mountain warfare ration test; DOD Food and Nutrition Research and Engineering Board, DOD Food and Nutrition RDTE and E Program, Natick, MA 25 May 1988.

MILITARY NUTRITION RESEARCH DIVISION

KEY BRIEFINGS:

Eldon W. Askew, LTC, Ph.D. Operational ration testing; MG McLean, Commander, QMS, General Officer In Progress Review, Combat Field Feeding System, Fort Lee, VA 1 June 1988.

Eldon W. Askew, LTC, Ph.D. Nutritional and performance testing; GEN Sennewald, Chairman of Army Food 2000 Task Force, Natick, MA Oct 1988.

John S.A. Edwards, MAJ, Ph.D. Cold weather MRE and supplement packet test; GEN Sennewald, Chairman of Army Food 2000 Task Force, Natick MA Oct 1988.

Eileen G. Szeto, CPT, MPH. A Comparison of Nutrient Intakes in Three Army Dining Facilities. Secretary of the Army Quarterly Physical Fitness Meeting. Washington, DC, Mar 88.

Eileen G. Szeto, CPT, MPH. A Comparison of Nutrient Intakes in Three Army Dining Facilities. Armed Forces Product Evaluation Committee. Natick, MA, Apr 88.

Eileen G. Szeto, CPT, MPH. Major sources of cholesterol, total fat, saturated fat, energy and sodium in the diets selected by soldiers subsisting in garrison dining facilities. Nutrition Education Cholesterol Subcommittee. Washington, DC, Jun 88.

Eileen G. Szeto, CPT, MPH. A Comparison of Nutrient Intakes in Three Army Dining Facilities. Army Nutrition Planning Committee. Washington, DC, Jun 88.

SIGNIFICANT TDY:

Eldon W. Askew, LTC, Ph.D. Delegate to Commonwealth Defence Science Organization Food Study Group Meeting, Kuala Lumpur, Malaysia, 25 Jan - 1 Feb 88.

Eldon W. Askew, LTC, Ph.D. Louisiana State University Grant Research Review, Meeting of Committee on Military Nutrition, Baton Rouge, LA, 12 Dec 1988.

John S.A. Edwards, MAJ, Ph.D. British Army Staff Convention, Washington, DC, 16-21 Oct 88.

Madeleine S. Rose, LTC, Ph.D. Attended The AMSC Mary Lipscomb Hamrick Research Course, Leesburg, VA, 10-11 August 1988.

USARIEM
CY88

MILITARY
NUTRITION RESEARCH DIVISION

SIGNIFICANT TDY:

Eileen G. Szeto, CPT, MPH et al. Garrison Dining Facility Study, Ft. Devens, MA January 1988.

Madeleine S. Rose, LTC, Ph.D. et al. Hot Weather Nutrient-Electrolyte Solution Field Test, Ft. Hood, TX July 1988.

Robert Rose, M.S. et al. Basic Trainee Garrison Dining Facility Study, Ft. Jackson, Columbia, SC August 1988.

Eileen G. Szeto, CPt, MPH. Attended the First National Cholesterol Conference in Arlington, VA November 1988.

SIGNIFICANT VISITORS

Colonel M.H. Daly, British Medical Liaison Officer, British Embassy, Washington, D.C. 13-14 October 88.

Commander Charles Gray, Naval Health Research Center, San Diego, CA 1988.

Brigadier R. D. Grist O.B.E. Military Attache and Commander British Army Staff British Embassy, Washington, D.C. 20-21 September 88

Dr. Chandan Prasad, Department of Medicine, Louisiana State University Medical School, New Orleans, LA.

Dr. William A. Pryor, Director, Biodynamics Institute, Louisiana State University, Baton Rouge, LA.

SIGNIFICANT EVENTS:

Major J.S.A. Edwards, British Army (Army Catering Corps) was assigned to The Military Nutrition Division, USARIEM as a staff liason officer for nutrition research.

PROFESSIONAL APPOINTMENTS/ACTIVITIES:

LTC Eldon W. Askew. Invited Reviewer for International J. of Sports Medicine and Journal of Applied Physiology.

MILITARY NUTRITION RESEARCH DIVISION

PROFESSIONAL APPOINTMENTS/ACTIVITIES:

LTC Eldon W. Askew. Review panel member for Sports Nutrition Publications, United States Olympic Committee, Sports Science Committee.

LTC Eldon W. Askew. Reviewer for Natural Sciences and Engineering Research Council of Canada, Research Grant Proposals.

Major J.S.A. Edwards, Member and United Kingdom Representative, NATO Panel 8, R.S.G.8. Nutrtitional Aspects of Military Feeding.

CPT Eileen G. Szeto, Member, Army Nutrition Planning Committee.

LTC Eldon W. Askew. Recipient of The Surgeon General of the Army's "A" Proficiency Designator in Biochemistry.

LTC Madeleine S. Rose. Recipient of The Mary Lipscomb Hamrick Army Medical Specialist Research Award.

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